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A Journal of Inter-Personal Relations

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Editorial Note

Dimensional Analysis of the Ensuing Articles

This issue of Sociometry was devoted to systematics by the permanent editor, and the guest editor has proposed in the preceding article that dimensional analysis be the systematizing principle. He is therefore responsible to show how dimensional analysis of each of the articles in this issue fits it into that dimensional system. To do this it is only necessary to write the dimensional version of the formulas or variables studied in each article. These dimensional formulas are all variants of the master dimensional formula for all sociometric data, concepts, or principles, namely:

$$S = T^{t} ; L^{1} ; P^{2} ; I^{1}_{pp} ; I^{1}_{r}$$ the quantic formula for any sociometric situation

Eq A

Where S = any recorded set of symbols, a "situation"
T = time
L = length of a line
P = people
I_{pp} = indices of interrelation of people
I_{r} = residual indices of any characteristics
; = any mathematical or logical operator

and the exponents may vary, usually from 0 to $\pm$ 3, except that, to be a sociometric situation p (the exponent on P) must be 2 or more.

This "quantic" formula classifies any and every sociometric situation, or set of interhuman data, into a) the five classes of dimensions (called "sectors") which are the five capital letters on the right hand in Eq A and b) their exponents (also called "quantics"). Further subclassifying is provided by the other three scripts but our dimensional analysis here will only go down through the first two levels of sectors and quantics. Every dimensional formula below, describing the contents of each article is a particular case of Eq A, obtained by assigning appropriate values to the several exponents. Terms in Eq A not appearing in the equations below disappear because they have exponents of minus infinity, if the term is an addend (since $X^{-\infty} = 0$), and of zero, if the term is a factor (since $X^{\circ} = 1$).

Stewart's article deals with population potentials in the United States, their compounds and correlates. A demographic potential is dimensionally a ratio of people to distance ($S = PL^{-1}$ Eq B). The product of two ratios is the demographic "force" of gravitation ($S = P^{2} L^{-2}$ Eq C). This force,

acting over distance L, becomes demographic "work" or "energy" ($S = P^2 L^{-1}$ Eq D). This energy index, given by the product of the two populations when divided by their intervening distance, Stewart finds, is correlated to rentals and incomes which suggests that such indices of economic wealth are dimensionally social "energy." Since Stewart and Zipf have also found various indices (I_{pp}) of interaction (such as telephoning, mailing, travelling, going away to college, etc.) to correlate well with this population-product-per-distance (P^2L^{-1}), the present indication is that such human interacting is, dimensionally, a form of social energy. Energy, classically has the dimensions of mass times velocity squared or, in social terms, $E = P\ I^2\ T^{-2}$ Eq E. Why "energy," thus classically defined, seems to equate with a population-product-per-distance in demographic gravitation is a major problem for further research.

Lundberg's article studies an interaction index ($I_{pp}\ T^{-t}$) based on choosing friends, with its conditioning variables which turn out to be partly compounds of time (T^{+1}) and space (L^{-1}) mixed with other characteristics. He defines an index relating the number of in-group and of out-group choices among college students and then reports how this index varies with college class, major, dormitory, scholastic level, socio-economic level, etc. (I_r). These correlations of an interaction index with residual indices gives a dimensional formula of $S = I^2\ T^{-1}$ Eq F. But his findings that the interaction index correlates best with indices which reflect *time* (T^{+1}) spent in common activity (e.g., college class, major, dormitory) and together, i.e., with least intervening distance (L^{-1}), relate his interaction index to time and space dimensions (among others, I_r^1) in a fuller dimensional formula of the form $S = I_{pp}\ T^{-1} \cdot (T^{+1};\ L^{-1};\ I_r^1)$ Eq G. This formula states that an index of interaction ($I_{pp}T^{-1}$) is correlated ($\cdot$) with an index of duration (T^{+1}, i.e., common experiencing), an index of proximity (L^{-1}) and with other indices, with any exponent, from the residual sector (I_r^1). (The matrix cross-classifying the interactants (P^2) is implicit as the interaction indices were computed from it, but since this matrix is not explicitly reported in this article, the P^2 does not appear explicitly in the formula).

Foa's article correlates one sociometric index with six non-sociometric indices and studies their growth curves. Among Yemenite Jews migrating to Palestine within the past seventy years, he finds an interrelation index (I_{pp}) of their friendships and six other indices of the residual class (I_r). The intercorrelations of these, neatly factored, gives a

type quantic formula for correlation (I^2). Their changing in logistic curves brings correlation in time into the study (T^{-2}). The summary dimensional formula is then $S = I^2 ; T^{-2}$, Eq H.

Cervinka's article (abstracted here) develops a dimensional theory of groups, using matrix algebra to analyze and then to synthesize any sociometric data. In addition to the interactants (P^2) and their direct interrelations (I_{pp}) in any group, he posits another class of dimensions (I_m) which mediate or condition the interrelations of the group. These "mediants," or reference entities, are Moreno's "criteria" for generating a group such as choosing one's interactants *for work, for meals, for roommates,* etc. A group thus mediated, Cervinka calls a "groupoid." His indices of solidarity and of cohesion in groupoids are matrix products of a) interacting persons, b) the mediants or group-generating stimulations, and c) the interrelating attachments which people have to each other and to these mediants. Dimensionally, this means his solidarity and cohesion indices are functions of interactants and correlations (I^2) between mediants and their corresponding interrelations, $S = P^2; I^2$ Eq I. (The novice in dimensional analysis is warned that an exponent of ^{2} does not mean a square exactly but rather a product with the base letter twice a factor. The product may be an arithmetic or algebraic product or a mean product or scalar product of vectors, or a matrix product or other variety of product).

Chandler's article relates an index of interaction in the subform of traffic accidents to the distance from home. His finding that this interaction correlates ($\cdot$) with inverse distance (L^{-1}) is dimensionally: $S = I_{pp} \cdot L^{-1}$ Eq. J. (Here implicit residual indices must enter in, even though not studied by Chandler, to the extent of the deficit from perfect correlation between accidents and distance).

The two articles by Boland and by Conant and Davis study the relation between the numbers of interactants. They find a correlation between the size of the publics (P_p) in a set of American communities and the number of their agents (P_a) for mass communication whether by newspapers or by radio stations: $S = P_a \cdot P_a^{P_p}$ Eq. K.*

*Here again, since the correlation of publics and agents is imperfect, the equation between them is a regression equation, implying the presence of unmeasured residual indices (1_r) to the extent of the alienation coefficient. In both of these papers and Chandler's also, the correlation between the base letters, the raw variables, should be computed and reported. This measures the *amount* of correlation in Equations J and K, whereas the correlation of logs, or exponents, reported in these articles only give the ratio of the exponents, i.e., the slope of the curve of correlation and states the *form* of correlation but not its amount.

In sum, the data in the articles in this issue are systematically classified by sectors and by the highest exponents of their dimensions as subcases of Eq. A as follows:

Article (Author)		Sectors					Quantic Number i.e., set of exponents
		Time	Space	People	Inter-relations	Residual indices	
Dodd	Eq A	T^t	L^l	P^p	I^i_{pp}	I^i_r	
		t =	l =	p =	i =	i =	t;l;p;i
Stewart	Eq B		−1	+1			0;9;1;0
	Eq C		−2	+2			0;8;2;0
	Eq D		−1	+2			0;9;2;0
	Eq E	−2		+1	+1	+1	8;0;1;2
Lundberg	Eq F	−1			+1	+1	9;0;0;2
	Eq G	±1	−1		+1	+1	19;9;0;2
Foa	Eq H	−2			+1	+1	8;0;0;2
Cervinka	Eq I			+2	+2		0;0;2;2
Chandler	Eq J		−1		+1		0;9;0;1
Conant & Davis	Eq K			+2			0;0;2;0
Boland	Eq K			+2			0;0;2;0

The exponents written as a single number are called the "quantic number" of that situation or set of data. (Negative numbers are written as complements from ten). Putting indices of interrelation and residual ones together gives a four digit quantic number. This quantic number serves to classify any and all recorded human phenomena in a definite dimensional class. With four sectors and five frequently occurring exponents (—00, 0, 1, 2, 3) the number of these classes is $5^4 = 625$. This quantic classification in dimensional analysis may prove very useful:

a) for ordering knowledge in a scheme common to every science.
b) for filing systems, library referencing, textbook chapters or other applications of a system in practise.
c) for guiding research in orderly ways whose semantic reliability can be, and has been, tested by controlled experiments.

STUART C. DODD
Issue Editor

A SYSTEMATICS FOR SOCIOMETRY AND FOR ALL SCIENCE

STUART C. DODD
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I. DIMENSIONAL ANALYSIS

This issue of SOCIOMETRY for May 1948 was devoted to "systematic sociometry" before a guest editor was invited and charged with getting articles contributing to systematics. This calls immediately for a statement of what systematic sociometry may be. This first paper therefore presents a system of sociometry, based on dimensional analysis. The first part of this paper applies the system to sociometry *internally* by analyzing sociometric data into their elementary dimensions. The second part applies this dimensional system to sociometry *externally* by analyzing all scientific data into dimensions similarly. This analysis shows the place of sociometry among the sciences by showing that when the general dimensional formula for all science takes on certain values, it becomes the special formula defining sociometry. The other papers in this issue explore these sociometric dimensions in particular combinations, brilliantly presenting tables of data and theoretical equations which fit and generalize those data towards developing sociometric laws.

II. INTERNAL DIMENSIONS—SOCIOMETRY SUBCLASSIFIED

Sociometry can be systematized by classifying all its data under five headings, or classes of dimensions, namely: *time, space, people,* their *interrelations* and all *residual indices* which condition the foregoing or correlate with them.[1] These five classes of dimensions, singly or in combination,

[1]In the language of mathematics this dimensional algebra is summarized in the following formula for all sociometry:

$$S = {}^{s}_{s}(T\ ;\ L\ ;\ P\ ;\ P\ ;\ I_{pp}\ ;\ I_{r})^{s}_{s} \qquad \text{Eq. 1}$$

where S denotes any set of data, any recorded symbols;
where T denotes duration of time;
L denotes length of a line;
P denotes people, the number of persons; and two sets of persons are required for there to be *interrelations,*
I_{pp} denotes indices of interrelations among people;
I_r denotes indices of all residual characteristics of people or of their environment, thus including everything symbolizable by the human mind in this set of dimensions without anything left out.

have been found by controlled experiments in semantics to be an adequate set of high reliability.[2] Although they were inductively derived from several thousand sets of data culled from all the social sciences, yet for brevity they are only summarily stated here, with deductive applications to the data of sociometry.

A. Time and space dimensions.

A dimension, first of all, is defined as an amount of something, a quantity of some quality or class. In primitive all-or-none form, anything one can name in any word becomes a dimension by considering it-and-its-absence. This makes a dichotomous variable of it and by calling its presence "1" and its absence "O" it becomes a numerical quantity, under the conditions specified. By observing its recurrences, percentages and frequency distributions are thus derivable from any and every qualitative entity or symbol. Thus anything human beings sense or know can be symbolized and dimensionally represented under specifiable conditions. Of course, this primitive all-or-none dimension should give way with research to more precise observing as in becoming an *ordinal* dimension expressed as "some," "more," "most" or in ranks, etc., or in becoming

; the semicolon, denotes any mathematical or logical operator, relating the letter symbols to each other, such as the $+ - \times / = \supset \cap \cup \sim$ signs, etc.

s denotes the scripts which, at the four corners, modify or describe their base letters in specified ways. The post superscript, or exponent, 1^s, denotes the number of times its base letter has been multiplied by itself, i.e., $L^2 = L \cdot L$, $L^3 = L \cdot L \cdot L$, etc. The post-subscript, 1_s, denotes classes or different kinds of dimensions; the pre-subscript, $_s1$, denotes class-intervals or units along one dimensions; the pre-superscript, $^s1$, denotes cases or points along a dimension. If these three scripts are on a base letter that has a zero exponent and hence denotes a logical class, (i.e., a quality or kind of thing) then they denote respectively a class, a subclass, and a member, or the "all," "some" and "one" of the older logic.

Each script on the parenthesis denotes the set, or list, of scripts on the base letters within the parenthesis.

[2]For details of the pioneer experiments measuring the adequacy and the reliability of this system of concepts see:

Dodd, Stuart C., *Dimensions of Society,* Macmillan, 1942, p. 742; *Systematic Social Science,* intermediate offset edition obtainable from the University Bookstore, 4326 University Way, Seattle 5, Wn., 1947, p. 785.

These two volumes develop this dimensional systematics for the social sciences in full.

the still more precise *cardinal* dimension expressed as a multiple of a standardized unit. Our words "first, second, third, etc.," denote ordinals, while "one, two, three, etc.," denote cardinals. Thus *anything* qualitative can, for scientific purposes of predicting and controlling phenomena, become dimensionally expressed or quantified with one of the above three degrees of precision (and with varying reliability depending on the conditions).

Time is the most universal dimension. Everything, whether material or symbolic, exists in time, aging or changing. Time is the variable most ubiquitous to the data of all empirical sciences. Those data may be observed at a point or instant of time and presented as static. Or they may be presented as a change in a period, a difference between two dates. Dividing the change by the time period measures a rate of change, the dynamic aspect of phenomena. A third subclass of temporal data arises when this rate changes, speeding it up or slowing it down. This is "celerating," whether accelerating or decelerating. All "force," "work," and "energy" as defined in physics and in sociology by dimensional formulas are concepts within this celerating subclass of temporal phenomena.[3]

All the interperson and intergroup relations of sociometry when they are dynamic, i.e., observed over a time period, become ***human interaction.*** The forms of interaction are the conventional social processes such as "cooperating," "competing," "conflicting," "associating," "assimilating," etc. All these and some thirty more social processes have been given operational definitions in dimensional formulas[4] which enable calculating

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[3]The algebraic statement of these temporal dimensions is:

$T^{-\infty}$ = O, time-to-the-minus-infinity power, a timeless situation, i.e., data holding for any and all times, or else with dates not specified;

T^{0} = 1, time-to-the-zero power, a date, i.e. instantaneous, or static phenomena

T^{+1} = a duration

T^{-1} = a time rate; time as a divisor (which is the meaning of a minus exponent)

T^{-2} = a celeration; twice divided by time

T^{-3} = a changing celeration, defining "power" in physics Eq. 2

In social data, time rates usually use a *year* or shorter duration as the unit (e.g., a birth rate, annual income, etc.); celerations usually deal with time series over *decades;* changing celerations often imply the longer movements of history, a social change or cultural development over *centuries.*

[4]The general algebraic formula for any social process is:

$$S = T^{-1} ; P^{2} ; I \qquad \text{Eq. 3}$$

which states the rate (T^{-1}) of change of some interhuman (P^{2}) index (I). This, of course, is a special case of the formula for any sociometric situation, Eq. 1, which

the amount of "competing," "accommodating," etc., and thus intercorrelating and predicting them.

Space is the next most universal dimension. All material entities exist in space. But symbols themselves and the abstractions they denote may have little spatial reference, while all symbols occur, recur, age, and change in time. Sociometric relations between people are conditioned by space as well as time. Spatial distance varying from face-to-face situations to complete separations limits the interacting of people, however much modern technology of travel and long distance communication reduces those limits. All ecology is only the spatial relations of organisms. Perhaps the firmest laws in sociometry, as discussed below, will emerge in terms of spatial distances. Spatial phenomena are subclassified dimensionally into places, distances, areas, and cubic regions, with varying amounts of each.[5] These are operationally defined by specifying the meter stick or other cardinal unit of length and "laying it off" at right angles to fix the length, width or height of any object. Similarly, operational definitions specify how to make a poll for an opinion dimension, or how to observe and calculate any statistic for the dimension which that statistic measures.

B. Population dimensions—the interrelated people.

Sociometry is here defined as the science of *inter*human relations. More literally the word means the measuring or exact observing of companions (socii), i.e., of *inter*related people. It includes interperson relations or intergroup relations or both. It excludes characteristics of people or relations of people to things or to anything other than people. Sociology includes these characteristics of people and their relations to non-human entities and hence sociometry is a subclass within Sociology. It is the subclass that deals *explicitly* and only with the internal structure and func-

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in turn is a special case of the formula for any human situation or set of data, Eq. 11B, which in turn will be seen below to be a special case of the general dimensional formula for all science or even for all symbolized knowledge, Eq. 11C. Our systematics thus attempts to reduce all data, all concepts, all principles in every science to dimensional formulas which stem back to a single master formula of highest generality.

[5]The algebraic symbols for spatial dimensions are:

$L^{-\infty}$ = o, a spaceless situation

L^0	= a point	$(= L^1/L^1 = L^{1-1=0})$	
L^1	= a line, a distance	$(= L^1 = L^1)$	Eq. 4
L^2	= an area	$(= L^1L^1 = L^{1+1=2})$	
L^3	= a volume	$(= L^1L^1L^1 = L^{1+1+1=3})$	

tioning of any group. For a group is here defined as any positively interacting set of persons or set of subgroups (whichever are its "members.")

A plurel is defined as any number (more than 1) of persons having at least one characteristic in common. It is thus a class in Logic (included within the including class "people"). All human groups are plurels but not vice versa, for every group is a subclass of a plurel. A group is a plurel, (i.e., any set of persons,) whose members interact among each other, i.e., have two-way stimulus-response relations, active or latent. To specify a group and to test whether a plurel is also a group, try writing it as a matrix. A matrix is any rectangular arrangement of items in rows and columns. Write the group's members, whether persons or sub-groups, as headings of columns and again as headings of rows (in the same sequence). Then write in each cell where a row and column intersect the relation or interacting (of one kind) of the row member with the column member. This constructs a second degree matrix of people cross classified with people. Thus any sociogram, when in matrix form, will enter an index of attraction (+ 1) or repulsion (— 1) or indifference (0) in each cell to express the attitude of the row person to the column person. A second degree matrix defining a group whose members are sub-groups (such as a league of athletic teams, or the United Nations) will list in the cells one class of interaction (such as scores of intra-league contests, or participation or non-participation in a specific UN agency). Then another similar matrix is needed for another class of interrelation among the same members (such as another year's intra-league contests, or participation in another UN agency). There will thus be as many second degree matrices as there may be different kinds of relations among the members. If there are i different relations the third degree matrix will be made up of second degree matrices i in number, like the pages of a book, each page recording a second degree matrix.[6]

[6]Matrices of still higher degrees will represent variation along still other dimensions. Thus the first degree matrix (one column) represents an array of people i.e., a population dimension; the second degree matrix adds rows of people, making a second population dimension; the third degree matrix adds "pages" of classes of interrelations making a "book" whose pages constitute a dimension of interrelations; a fourth degree temporal matrix adds "books" one for each date or period, making a shelf of books which constitute a time series or time dimension; a fifth degree spatial matrix adds "shelves," one for each geographic region, making a "tier" of shelves which constitute a spatial series or spatial dimension. Matrix algebra provides the rules for adding or multiplying, factoring or solving for the roots, and other operations with matrices. For initial applications of matrices in sociometry see the author's

Now the matrix is essential for exact sociometric analysis. Matrix algebra is the mathematics best adapted to analyze the human group, which is here defined as any set of interrelated but separate members. A sociogram can graph simple sociometric data vividly, but cannot handle those data when numerous or complex, or needing exact treatment. The matrix can have arrays, even to millions in number, for persons and any combinations of persons and any higher order combinations of groups. All these are handled by matrix algebra with the rigor and precision of the more familiar arithmetic.

But even more importantly, the matrix *tests* when a set of people is a group and when it is not a group. If the data can be expressed as a first degree matrix, (i.e. a simple list of the amount of a characteristic possessed by each member of the population) it is a non-group plurel. The data are simply a frequency or other distribution. But the data represent a group if, and only if, a second degree matrix of people cross-classified against people, showing their *inter*relations in the cells, is essential. This test, whether explicit or implicit, will define what is "sociometric" and keep the term from becoming blurred into meaning "any measurement in sociology".

For classifying sociometric data along populational dimensions the first order class is a set of interrelated persons which might be called a "grouplet". The second order class would be a set of interrelated grouplets such as a league of athletic teams. A third order class would be composed of second order classes as members and so on up to any nth order. A group of second or higher order might be called a "grouping", i.e. a group of groups. Then a mixed group having as members both persons and groups of any orders might be called a "groupage". Corporations, government departments and many other human groups are groupages wherever within them individuals are coordinate with subgroups in being members of a higher order group. A "group" then is a general term with subclasses as "grouplets", "groupings", or "groupages" according as the members are persons, sub-groups, or both, respectively.

"The Interrelation Matrix" (SOCIOMETRY, Vol. III, No. 1, 1940), "Analyses of the Interrelation Matrix by Its Surface and Structure" (SOCIOMETRY, Vol. III, No. 2, 1940), "Dimensions of Society" (Macmillan, 1942, Chapter 7), "Systematic Social Science" (University Bookstore, Seattle, 1947, Chapter 5) and Katz, Leo, "On the Matric Analysis of Sociometric Data," (SOCIOMETRY, Vol. X, No. 3, August, 1947). Cervinka's paper in this issue SOCIOMETRY (May 1948) applies matrix algebra to his dimensional theory of groups.

Finally, a "social organization" may be defined as a "tri-partite" group or third degree matrix of three populational dimensions. Thus in any institutional organization there are three kinds of subgroups interacting—namely, the agents, the clients, and the public. The agents or leaders and specialists do most of the acting in the interacting of that group. They are such interacters as doctors, teachers, sellers, priests, parents, etc Then the clients or interactees are the people acted *on* largely. They are the doctor's patients, the teacher's pupils, the seller's customers, the priest's congregation, the parents' children, etc. Then the third subgroup in any social organization thus defined is the relevant public, the persons *for* whom the interacting goes on. The public is indirectly or potentially or at some time clients since anyone may become sick, or have been a pupil, or be a customer, etc. The public is a latent clientel. These three subgroups represent "people acting", "people acted on", and "people acted for" chiefly. Together they and their interacting constitute a social organization implying formal specialization and exchange of functioning and of its benefits. Social organization then is specifiable explicitly by a third degree populational matrix cross-classifying agents, clients, and publics.[7]

C. Interrelation dimensions.

The indices of interrelation between people are the heart of sociometry. They are the entries in the cells of the matrix. Their existence proves those people to be a sociological group. What then are these interrelations and how may they be systematically classified?

Interrelations and their dynamic subclass, interactions, are primarily stimulus and response relations between persons. They are attitudes of the row persons in the matrix towards the column persons, or behavior of the row persons stimulating the column persons, or setting up situations which influence the column persons. These direct and simple classes of interrelation then may become complicated by varying along any of the

[7]The algebraic symbols for the populational dimensions are:

$P^{-\infty}$ = a populationless situation; no people recorded in the data;

P^{0} = a person, the field of individual psychology;

P^{1} = a plurel, the field of demography;

P^{2} = a group, the field of sociometry, a group is a product of people and people; more exactly a matrix of logical products as the cells entries (and often psychological products as in an attitude of A to B where A is one psychological "factor" and B is the other).

P^{3} = an organization o fpeople, a triple mean product of agents, clients and publics.

dimensions. A partial catalogue of such variation classifies them under the five sectors or classes of dimensions which are necessary and sufficient for sociometry, namely, time, space, people, interrelations proper, and residual indices. Let each be reviewed in turn:

1. Interrelations and time. Time and space are usually variables which condition interrelations, or correlate with them, but are not often themselves the index of interrelation that is entered in the cells of the interhuman matrix. Time usually figures as a divisor making each cell entry a time rate, a speed of the interaction between the row and column people. The duration of the period may be unstated and then the index of interrelation is merely asserted to transpire in time and be a dynamic one, an interaction of some kind. Time thus subclassifies interrelations into the static ones and the dynamic ones, the ones observable at a date and those observable only in a period.

Next, the sequence of the interrelations in time is a necessary factor in causal interrelations. Causes precede their effects. Antecedent interrelations (A) may be causes of later events (B) which of course can never be caused by still later events (C). For if causation is defined as a brief term for the three necessary and sufficient conditions of antecedence in time, correlation, and duplicability of the specified circumstances, then the time dimension is essential in any analysis of causation. And all a "stimulus" and a "response" mean is a cause and an effect in an organism. Hence interaction of people, being largely interstimulation and responding, involves causation and so the time dimension. Of course, causal analysis becomes complicated when the interactions or other events are concurrent and not successive. And most social actions are concurrent so that special observational and experimental technics are required to get interactions in sequence and to explore for causation in observing antecedent changes of speed correlated with consequent changes of speed in concurrent processes. Correlation of two time series is necessary to show causation but not sufficient as correlation may exist without causation, of course.

Interrelations may be distributed irregularly in time having periods of presence, or activity, and periods of absence, or latency. Any group meets at times and remains more latent between its meetings or between its periods of activity. Occasionally, time is the cell entry directly as when the interrelation is a time interval between some actions of the row and column persons. Thus, if rows represent employers and columns represent employees, the interrelation in each cell might be the length of employment of each employee with each employer.

In sum, interrelations are classified by the time dimension into at least the following temporal subclasses:

interaction and static interrelations;
varying speeds and celerations of interaction;
causal interacting and varying correlation of time series;
active and latent interrelations, temporal distribution of events;
durations of interrelation, ages.

All of these can be expressed more rigorously in algebraic formulas using the appropriate exponents and other scripts.

2. Interrelations and space. Interrelations of people are spatially conditioned. The intensity and frequency of a specified class of interrelation is commonly expected to decrease with the distance separating the interactants. The intimacy of interrelation between parent and child decreases as their average distance apart increases from least distance in the womb to more in the child's home to most after the grown child leaves the parental home. Primary versus secondary groups, or face-to-face versus dispersed groups reflect the effects of distance. Our senses of kinaesthesia, taste, touch, smell, hearing, and sight vary in that order in the distance they overcome in interrelating organisms. Modern transportation and communication reduces distance absolutely but not relatively. Thus the airplane makes the antipodes nearer to us than the next county may have been to our grandfathers but even *by airplane* the antipodes are still relatively further than the next county. Technology increases human interacting at a distance but people still interact at short distances more than at long distances.

This folk generalization is becoming measured as an exact law. Studies such as those of G. K. Zipf and J. Q. Stewart show high negative correlations between amounts of various types of interacting and the distance between the interactants. These interactions include telephoning, sending mail or parcels, travelling between communities, a newspaper's circulation in other communities, a university's enrollment from other states, etc. Stewart has formalized this tendency in the concept of a "population potential" which is a ratio of the number of persons divided by the distance between those persons and the point for which the potential is stated. His paper in this issue reviews much of these formulas showing how compounds of potentials define demographic "force", and demographic "energy". Demographic energy, in turn, correlates highly with, and therefore predicts, various indices of wealth, birth rates and other vital statistics. These studies are piling up evidence that interhuman action tends to be inversely

proportional to the first power of the intervening distance. (Closer fits of data to this expectation may result when "distance" is measured in units of effort in time or cost of travel and not always in units of miles.)

Human interacting is also well known to be related to the second power of lengths expressed as area. For a given population, the smaller the area the more the interacting. With a population of a fixed size, in a large area the population is sparce, interperson distances are large, and interacting is less than in a small area with small interperson distances and a dense population. The exact regression co-efficients relating the amount of interacting of each kind to the density of the population is a fertile field awaiting further research. Social laws of interaction conditioned by density may be expected. These laws may parallel for people the laws for gas molecules (on a two dimensional surface).

3. Interrelation and population. The interrelation indices entered in the cells of the sociometric matrix may be frequencies of persons when each row and column represents a group and not a person. The population frequencies in each cell will be the number of members common to the row group and the column group. The cells measure the overlap or shared membership of every pair of groups. This common membership also measures the correlation in each pair of groups.[8]

It is to be expected that any two groups will tend to have similar interactions (or similar behavior and characteristics of any kind) at least to the extent of their "common member correlation". When this correlation is unity, the two groups have identical membership and their members must show identical behavior (of any specified kind) when compared with themselves. When this correlation is zero, the two groups have no common members and may, or may not, show similarity in the behavior of their members.

A major sociometric law emerging from Zipf's and Stewart's studies is that the amount of interaction between two community groups tends to be proportional to the product of the two populations of those communities. The larger the product of any two plurels the more the interactions (of a specified class) between them. This is to be expected from probability

[8]Among plurels, f in number, the matrix will have f rows and f columns and $(f^2 - f)/2$ correlations (excluding the self-correlations of unity in the main diagonal cells). The formula for this common members correlation coefficient is the geometric mean of their two proportions namely $r_{12} = P_{12}/(P_1P_2)^{.5}$, where P_{12} = the plurel common to plurel 1 (P_1) and plurel 2 (P_2).

theory. This principle can be deduced rigorously as the most probable result of random interacting.[9]

Now it is possible to combine the inverse distance principle and the population-product principle to get a more accurate formula for predicting the interacting of any two communities. This principle is: *Other things being equal, the amount of interacting of a specified kind between two communities will be proportional to the product of their populations divided by their intervening distance.*[10]

Since "other things" are usually unequal, these other things, or disturbing variables, will reduce the correlation between the interaction and the population-product-per distance. There will be a regression equation whose standard error of estimate will measure the disturbing variables. These disturbing variables may be such as differences between communities in education, wealth, language, separation by national boundaries, or by other barriers. In proportion as these disturbing variables are measured and included in the formula by multiple regression methods, the formula predicting the interacting of communities should become more accurate.

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[9]For if each person in a population of P persons has on the average an equal share of all the interacting, his share will be 1/P th of the total amount of interacting. The probability of his interacting with any other specific person is the product of their two probabilities namely $1/P \cdot 1/P$. Adding these probabilities for each community, P_1 and P_2 in size, and then multiplying them to get the joint probability ($_{\%}P_{12}$) of intercommunity action gives

$$_{\%}P_{12} = P_1 P_2/P^2 \qquad \text{Eq. 7}$$

As $P_1 + P_2 = P$ by definition, each ratio, P_1/P and P_2/P, is less than unity and their product therefore will always be a probability less than unity. This product is the proportion of all the interacting (of the people in the two communities) which is interacting *between* the communities. The complementary proportion, $1 - P_1P_2/P^2$, is the interacting of the specified class *within* the communities. In comparing the amounts of interaction in the communities of a nation, P is the national population. Then the denominators are all the same and may be neglected as a constant leaving the volume of interacting in each pair of communities proportional to the product of their sizes, P_1P_2.

[10]The algebraic statement of this incipient law of demographic gravitation, as Stewart calls it (see p.), is the regression equation

$$I_{pp} = r\, P_1P_2/L^1 \qquad \text{Eq. 8}$$

where I_{pp} is an index of interaction of some specified kind between populations, P_1 and P_2, separated by distance L. r is the correlation between I and $P_1\, P_2/L$, both being in standard deviation units. I_{pp} here is its estimated value and will be, about 2/3 of the time, within a standard error of estimate of its observed values in any given set of communities.

4. Interrelations and interrelations. The interrelations of people which define a group in sociometry have been subclassified above along dimensions of time, of space, and of population. It remains to subclassify interrelations in terms of other interrelations and in terms of the residual indices sketched above in our five classes of all possible dimensions.

Interrelations may be subclassified with greatest generality of use into five classes according to the exponent, paralleling the exponent subclasses of time, space and people above. The exponents classify any situation, i.e., any set of data, into a) situations without any interrelations of people, b) situations with qualitative interrelations, c) situations with quantitative interrelations, d) situations with pairs of correlated interrelations, and e) situations with trios of correlated interrelations.[11]

This classification of interrelations (and also of all the residual class of indices) is based on the thoroughness with which they have been observed and recorded. Least thorough observing is the qualitative level which merely discriminates some *kind* of interrelation, such as "attraction-repulsion attitudes," "converses with," "gives professional service to," etc. More thorough observing measures that kind of thing, or class, expressing that quality as a quantitative variable. Still more thorough observing notes its relations and measures these in correlation indices. This yields regression equations and thus predicting the interrelations (with given probability) becomes possible—and the scientists' aim of predicting and controlling phenomena is approached. The fifth class of triply correlated interrelations involves more thorough observing than social scientists have yet achieved. As better methodology becomes developed, such triple correlations will become observable in various forms. One form seems likely to be what is currently called "social control." For our theory of social control[12] analyses it as a two-stage interrelation of controllers and con-

[11]The algebraic statement for these interrelational indices and also for indices of the residual class is:

$I^{-\infty}$ $(=0)$ = index absent, an 0 index Eq. 9
I^{0} $(=1)$ = a qualitative index, a class in logic, a kind of —
I^{1} $(=I)$ = a quantitative index, an amount of I^{0}
I^{2} $(=I \cdot I)$ = a correlation of two indices, their mean product or scalar product
I^{3} $(=I \cdot I \cdot I)$ = a triple correlation, as in "social control" among an index of the controllers' *intention*, an index of the *instruments* of control and an index of the *influence* on the controlees.

[12]For detailed exposition of this theory and indeed of all the system summarized in this paper the author's "Systematic Social Science" cited above should be studied.

trolees involving the triple correlation of three observed indices (of the controllers' *intentions,* of the *instruments* of control, and of the *influence* on the controlees).

In addition to subclassifying human interrelations on the basis of *thoroughness* of observing them (as specified by the exponent), they may also be usefully classified on the basis of their *reciprocity* and their *mediacy.*

Reciprocal interrelations are two-way relations. Each member of the group stimulates others and responds to others; there are positive indices entered in the cells on both sides of the main diagonal in the interrelation matrix. In contrast to this full two-way interaction there may be one half or one-way interaction, which is called "contact," and there may be no interaction or "isolation." Contact is illustrated by the one-way influence of the past generations after their death, upon the living—who can no longer influence the dead. Contact is defined and measured by indices only on one side of the main diagonal in the interrelation matrix. Isolation is defined and measured by indices only in the main diagonal cells, showing only relations within the member, whether a person or a subgroup, and no relations with other members listed in a given matrix.

While many contact matrices have been published reporting social distance attitudes, etc., very few full two-way matrices have been published. A recent search of the literature by Mr. Raymond Bassett uncovered only a dozen publications of them—an astonishing dearth of sociometric data for a decade's research by sociometrists.[13]

Rigorous inducing of principles of human interrelations awaits fuller data; sociometric laws must be based on observed matrices. So far only hints at such laws have been published as in Dodd's finding of "ambition" versus "familiarity" factors operating in social distance attitudes among a college student population in the Middle East.[14] These "ambition" and "familiarity" factors recur throughout Lundberg's data reported in this issue.

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[13]Towards building up a body of two-way matrices for sociometric induction, it is suggested that whenever one publishes a sociometric study, the full data giving every interrelation observed and not merely selections in the usual sociograms be made available to other sociometrists. By sending the data to Bibliofilm, American Documentation Institute, Dept. of Agriculture, Wash., D. C., it can be microfilmed and ordered thereafter by anyone for one cent a page. The document number of the Bibliofilm should be published in the printed report. In this way in a few years enough matrices might be collected cooperatively to enable firm induction of sociometric generalizations.

[14]See Dodd, S. C., "A Social Distance Test in the Near East", *American Journal of Sociology,* Vol. XLI, No. 2 Sept. 1935.

Interrelations may be subclassified on the basis of their *mediacy*. They may be immediate or mediated in varying degrees. They may be direct attitudes of persons to persons or indirect attitudes as when people feel loyal to a group in which the attitudes of the members are directed primarily towards the leaders, the name and symbols of the group, its history and ideals, its site and its activity and only secondarily to fellow members, personally. This mediating of inter-member relations may go as far as complete ignorance of one's fellow members. This is a common type of group as illustrated by the group of patients interacting with one doctor, the customers interacting with a mail-order firm, the citizens of a large nation who may know personally only a couple of persons for every million of their fellow nationals. The sociologist's "primary vs. secondary" groups is largely this difference between immediate vs. mediated interrelations of people.

A pioneer attempt to study mediated groups with mathematical exactness is Vladimir Cervinka's paper summarized in this issue. His dimensional theory of groups expresses in matrices not only all immediate interrelations between the members but also all mediated interrelations in order to represent and measure the group's structure more fully. The rows and columns of his matrix provide for every member (and combination of members in any subgroups) and also for every group-generating mediant such as titles, offices, sites, activities, traditions, programs, hopes in common, or any other group-binding stimulus to which the members' nervous systems may be conditioned. To measure the "solidarity" of a group he then measures the attitudes (by a suitable attitude test he proposes) of every person to every other person *and to every mediant* and summarizes these indices, duly weighted, by matrix multiplication into a net index of solidarity of the given set of persons.

The interrelations of people may be classified in many other ways depending as in all classification upon the classifier's purpose. The purpose in the above classifications has been the general one of science—to further the predicting and controlling of phenomena by observing them by more objective, reliable, and exact technics to which the concepts of "dimensions" and "matrices" contribute.

But for many purposes classification of human interrelations by their content may be more useful. Grouping them under the chief social institutions is perhaps the commonest basis of classification. This means: family interrelations, economic interrelations, political interrelations, educational interrelations, religious interrelations and so on for the institutions

of health, welfare, recreation, art, science, and communication, etc. Other alternative classifications are legion and cannot be reviewed in an article. But however numerous these classifications may be, dimensional analysis can combine them all simultaneously. For each basis of classification is a dimension, recordable by an index in the formula. The formula can comprise as many indices as there may be kinds of interrelations or properties of them to be recorded.

The dimensional system for sociometry may now be brought together in a conspectus. The foregoing exposition can be succinctly summarized in a tabulation giving the dimensional subclasses by sectors first and by

The Dimensions of Sociometry[15]

SECTORS, OR MAJOR CLASSES OF DIMENSIONS				
Subclassified by the *Exponent* script, 1^s	Interrelations + residual conditioning indices I	People P	Time T	Space L
Nul classes $-^{oo}$	No interrelations I^{-oo}	No people P^{-oo}	No duration T^{-oo}	No space L^{-oo}
Qualitative classes 1^o	a class (in Logic) I^o	a person P^o	a date T^o	a place L^o
Quantitative classes 1^1	an index I^1	a plurel P^1	a speed T^{-1}	a distance L^1
Correlative classes 1^2	a correlation I^2	a group (essence of sociometry) P^2	a celeration, also a "force" and "energy" T^{-2}	an area L^2
Higher order classes 1^s+	a control I^s	an organization P^s	a power? (evolution?) T^s	a volume L^s

[15]The dimensional formulas may be algebraically stated for all data, concepts and principles of

Sociometry: Eq. 11A : *Sociology*: Eq. 11B : *Science*: Eq. 11C

$S = {}^s_s(T;L;P^s;I_{pp};I)^s_s$; $S = {}^s_s(T;L;P;I)^s_s$: $S = {}^s_s(X;)^s_s$

a special case of →: a more general case of →: the most general formula

Eq. 11A means the interrelations of people in time and space, (as explicitly recorded in any given set of data, S).

exponents next, (leaving further subclassifying by classes of content to each study as needed). The reader is warned that the phrases in this tabulation below can only approximate the exact meaning of the exponential classes whose more exact meaning is better stated in algebraic formulas with all they imply.

III. External Dimensions of Sociometry—Science Subclassified

The external dimensions of sociometry place it among the sciences. They classify sociometry as a subclass of sociology which is a subclass of the empirical sciences which are a subclass of all science. This is best seen with exactness by starting with the completely general dimensional formula (Eq. 11C) and step by step deriving each science from it in turn down to sociometry.

The universal dimensional formula classifies any and every set of symbols representing anything that human beings can symbolize into three classes of symbols, namely, substantive symbols (X), operator symbols (;) relating substantive ones to each other, and script symbols (s) modifying the substantive ones (Eq. 11C). Developing the exponent scripts first specifies the three Kantian categories in metaphysics namely, quality, quantity, and relation. Other scripts develop Kant's subcategories specifying in exact algebraic terms this well known classification in philosophy.

Next, the field of logic becomes specified by a zero exponent and the field of mathematics by a non-zero exponent. Differentiating or separating the generalized dimension, X, into specific subclasses beginning with dimensions of time and space then differentiates the separate empirical sciences. When X's are subclassified into space, L, and residual dimensions, geometry becomes specified. When time is further separated out from this residual category, kinematics becomes specified. When mass is next subclassified or separated out from the residual X's the dimensional formula involving mass, time, space and subsuming all physical formulas is specified. When atoms are separated out from the otherwise undifferentiated residual class of dimensions, chemical formulas become specifiable. When from the residual class of dimensions, organisms are next separated out, biology and all its contents become specifiable in dimensional formulas. When next, people are separated out from the class of all organisms, the human sciences becomes specified and the dimensional formula for all science, Eq. 11C, has been limited to its subformula for the human sciences, Eq. 11B. When finally, the population sector in this last formula is further

limited to its subclass where the exponent is two, then interrelations of people and the field of sociometry becomes specified.[16] (Eq. 11A)

This much-condensed sketch gives a notion of how dimensional analysis orders the sciences. And a major function of science is to bring law and order into man's knowledge of the universe. This sketch does not show the logical derivation of these formulas. Nor does it show how each is a master formula for one science subsuming as special variants every set of data, all concepts, all formulas, and all principles, in its science. It does not show the empirical evidence supporting the large claim made in the last sentence. It does not show the controlled experiments in semantics whereby reliabilities of .97 to .99 were found for this dimensional systematics, i.e. two analysts independently writing dimensional formulas (analyzed down to sectors and exponents only) showed only 3% to 1% of discrepancies. It does not show how all language yielded to dimensional analysis with the discovery that 50% of all spoken or written language seems analyzable into ten dimensions, or all-or-none elements of meaning. These ten dimensions are an alphabet of meanings and suggest enormous possibilities for a simpler, more flexible and more precise universal language of the future. Such a streamlined language may eventually displace current languages as fully as the decimal digits displaced Roman numerals.

The sketch here of dimensional analysis of all science is too brief to show its utility. To do this would require longer treatment of how it enables data to be more precisely expressed whether at the qualitative, all-or-none, ordinal, or cardinal degrees and so contributes to developing an exact science out of whatever field is dimensionally analyzed. To show its utility further requires showing how, while dimensional systematics was induced from thousands of sets of data, yet it is a rigorously consistent system of concepts permitting logical proofs of theorems, deductions of

[16]The algebraic form of these dimensional formulas for the sciences are:

Any set of symbols	$S =$	Eq. 2
All dimensions	X	Science
Space separated out	$L;X$	Geometry
Time separated out	$L;T;X$	Kinematics
Mass " "	$L;T;M;X$	Physics
Atoms " "	$L;T;M;A;X$	Chemistry
Organisms " "	$L;T;M;A;B;X$	Biology
People " "	$L;T;M;A;B;P;X$	Human sciences*
—Groups	$—P^2$	—Sociometry

*In Eq. 11B, M, A, B, here are lumped with X under the sector called "residual indices."

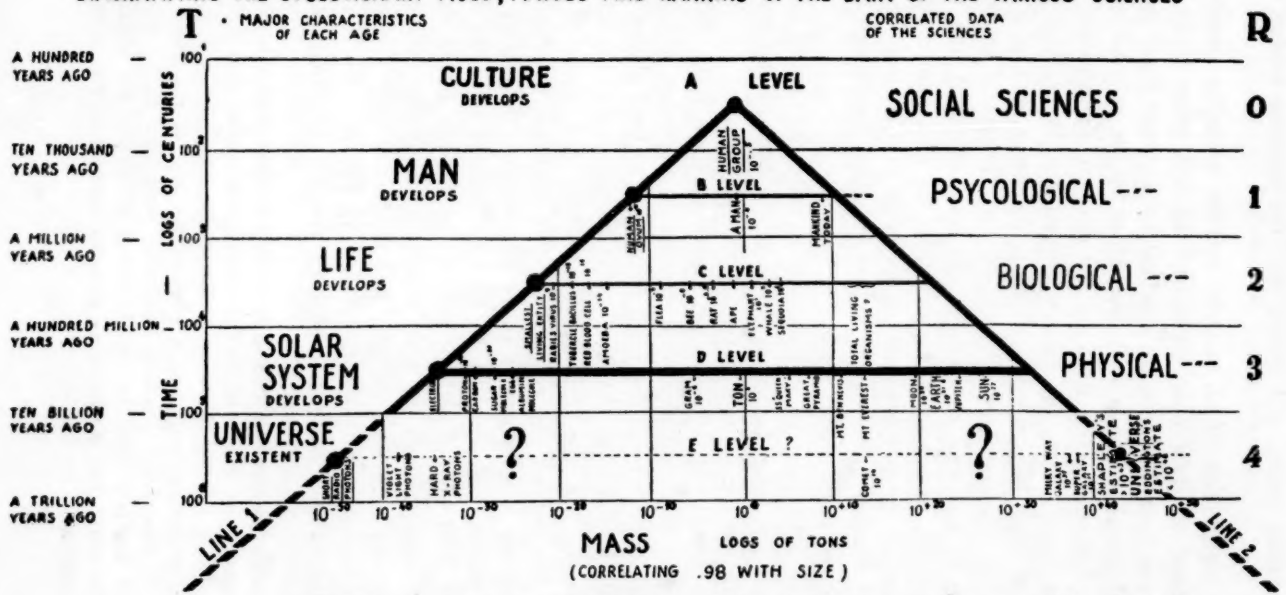
new relations to be empirically tested, and the solving for unknowns, even in qualitative and social problems. Further evidence of its utility is in the operational, and hence more reliable, definition it has enabled for several hundred of the chief technical concepts in sociology, just as it has previously served in physics to provide a unifying conceptual framework, into which all physical concepts and definitions and formulas can be translated. But the main utility of dimensional analysis seems to the author to be in bringing more law and order into the often unrelated masses of confusing data in the younger sciences. Of this contribution to ordering phenomena one concluding bit of evidence will be given below. It is a dimensional analysis of the cosmos which unexpectedly develops great regularity, expressible in a simple equation, and arranges the sciences including sociometry in simple relation to each other.

To understand this cosmic dimensional analysis presented in Figure 1 the data distributed within its isosceles triangle, and its two coordinates must be understood. The data are all material entities from quanta of energy (which have mass) up through protons, atoms, molecules, crystals, organisms, people, planets, stars, and galaxies to the entire universe. Each entity is placed long the horizontal axis according to its mass (or alternatively according to its mean spatial size as mass and size correlated at .98 showing them to be roughly interchangeable on this cosmic scale). The scale of masses is a logarithmic one requiring 100 log cycles or with one hundred zeros written after it. The base unit of mass, M, is a metric ton which occurs at the middle of the scale. Vertically the entities are distributed at the midpoints of their class intervals (to minimize error) along either of two closely correlated dimensions. One dimension is the rank of the science (at right in Fig. 1) from 0 for the Social Sciences at the top of the diagram to 4 for astronomy at the bottom. This ranking is by logical inclusions of classes: the symbol using human "group" (the data of the social sciences) being included in the class "human" which is included in the class of "organisms" (the data of biology) which is included in the class "material" objects (the data of the physical sciences).[17] Closely correlated with this ranking dimension is the time dimension measured back from the present in logarithms of centuries. This classifies the entities studied in each science into class-intervals of their evolutionary age. Thus symbol-using human groups developed in the past ten thousand years,

[17]Fuller presentation of this "mass-time triangle" is given in the author's "Systematic Social Science," cited above, Chapter 17, and in his "A Mass-Time Triangle," *Philosophy of Science,* Vol. II, No. 4, October 1945 (where the coordinates of points are misstated in the equation).

A MASS-TIME TRIANGLE

DIAGRAMMING THE EVOLUTIONARY AGES, MASSES AND RANKING OF THE DATA OF THE VARIOUS SCIENCES



LINES 1 AND 2 : LOG M = ± 11 (LOG T - 1.5) OR LOG M = ± 11 R

DATA FROM, "THE STUFF WE'RE MADE OF", W. O. KERMACK & P. EGGLETON, SCIENCE BOOK CLUB, 1938
"FLIGHT FROM CHAOS", HARLOW SHAPLEY, Mc GRAW-HILL, 1930.

STUART CARTER DODD

homo sapiens in the past million years, living creatures developed mostly during the past hundred million years, our solar system was born during the past ten billion years, and before that the universe existed in some form.

Now the distribution of all material entities, including people, in the comos as defined on these coordinates of time and space is an isosceles triangle. Its two bounding lines are specified by a simple linear equation.[18] The left hand bounding line is well determined by the minimal entities at each level in Figure 1. It is fixed by the electron, the smallest physical entity having "rest" mass, the viruses around the lower limit of living entities, the fertilized human ovum which is the lower limit of a complete human, and the minimal human group of two persons. The right hand bounding line is less well determined. It may represent the maximum limit at each level. It predicted, for example, the maximum at the lowest level—the mass of the universe—as of the order of 10^{44} tons before Professor Harlow Shapley informed the author that that figure was about the best estimate astronomers had made.

It may be of interest to sociometrists to note the central position of their field since the mean human group is at the apex of the triangle and at the midpoint on the scale of mass (or also of size).

We have no rational theory as yet explaining these facts. Why should the compounding in complexity seem greatest in midrange and not go on increasing with size? Why is the jump from level to level eleven log cycles every time? Why should the choice of our origin points and log scales result in manufacturing (to use Eddington's phrase) the observed isosceles regularity in the data of the cosmos? If this isosceles distribution stands the critical review of scientists as to its assumptions, definitions of terms, and plotted points, will equation 13 be considered a scientific law about the universe? Will further periodic regularities emerge within the triangle as a sheaf of lines through the apex making equal angles with each other and subclassifying each level usefully and proportionally? These questions await further research. At present, the data of Figure 1 are recorded here as a contribution of dimensional analysis towards systematizing science.

[18]The algebraic statement of this isosceles distribution of "material entities" in space and time is:

$$\log M = \pm 11 R \qquad \text{Eq. 13}$$

where M is metric tons of mass and R is either the rank of the science or the log of centuries. In dimensional simplicity, neglecting coefficients stating the units, and the location of the zero point in the mid-range of masses, this equation reduces to L = T. This states that, in this cosmic situation recorded by Fig. 1, linear space is dimensionally equivalent to time.

DEMOGRAPHIC GRAVITATION: EVIDENCE AND APPLICATIONS

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1. *Agenda for Social Physics*

In the study of matter, physicists have two valid points of view, the macroscopic and the microscopic. The macroscopic view presents a gas as a continuous medium, and describes its physical condition in terms of such "field" quantities as density, pressure, temperature, gravitational potential. The microscopic view recognizes that a gas is made of a huge number of separate molecules. If observational attention could be focused on the rapid and intricate movement of a single molecule, bouncing against the others, there would be no hint to be gained, from its momentary velocity, momentum, or kinetic energy, as to the value of the temperature or pressure. And a physicist who insisted that the gas as a whole could be studied only by making a detailed point-to-point and instant-to-instant record of the paths of typical molecules would find his ill-chosen task impossibly laborious.

Fortunately for physics, the macroscopic approach was the commonsense one, and the early investigators—Boyle, Charles, Gay-Lussac—were able to establish the laws of gases. The situation with respect to "social physics" is reversed. If we liken people to molecules, the commonsense approach is the microscopic one—involving the study of mutual relations and reactions of individuals or of very small groups. Many experts in the social field nowadays are willing to adopt a scientific rather than a dogmatic attitude, attempting to study people as they really are rather than to set up and enforce an ideal geometry along some party line. But progress has been very slow because they always insist on knowing too much.

The late Sir James Jeans in a book about the kinetic theory of gases gave a spectacular illustration of the properties of large numbers. He pointed out that there are about 10^{44} molecules in the whole atmosphere of the earth, while a single breath of air contains something like 10^{22} molecules. If the assumption is made that by now the air once breathed by Julius Caesar is uniformly distributed throughout all the atmosphere, the probability is that every breath any one of us draws contains several molecules which were included in Caesar's last breath. If Robert Boyle had taken the attitude of many social scientists, he would not have been willing to measure the pressure and volume of a sample of air until an encyclo-

pedic history of its molecules had been compiled. Boyle did not even know that air contained argon and helium but he found a very important law.

Merely verbal methods of description and analysis are all that are at the command of most students of society. These are powerless to formulate the quantitative averages which are required for the macroscopic approach to sociology. Continued insistence on examining people's purposes and motives only blocks the way to a science of society as a whole, just as similar sentimentality and animism in Aristotelian physics made that physics useless century after century.

On the other hand, mathematics, even mathematical statistics, unaccompanied by a feeling for physical or social reality is incompetent to create useful patterns of concepts for the organization of the suggested new discipline of social physics. To the pure mathematician all things are possible and he is ignorant of restrictions which must be accepted if mundane applications are quickly to be made. If the results of mathematical economics thus far have been disappointingly minor, the reason is that economists have not furnished mathematicians with adequately abstract and dynamic economic concepts for manipulation.

2. *Newtonian Gravitation*

Newton's law of gravitation may be expressed in any one of three different formulas. In the following presentation the name of each physical quantity is italicized when first introduced.—Suppose a particle of *mass M* is at point A, at *distance d* from a second particle of mass *m* at point a. A *force F* acts on each mass, attracting them together along the line joining them, and having the magnitude

$$F = \frac{GMm}{d^2}, \tag{1}$$

where *G* is a universal constant, the *gravitational constant*. This was Newton's original statement.

The mutual *energy* of the two masses in the gravitational field is *E*, given by

$$E = \frac{GMm}{d}. \tag{2}$$

Finally, the gravitational *potential* V_A which the mass *m* produces at point A is

$$V_A = \frac{Gm}{d}; \tag{3a}$$

and the potential V_a which M produces at a is

$$V_a = \frac{Gm}{d} \cdot \frac{GM}{d} \tag{3b}$$

The concept of potential was first introduced by Lagrange.

A comparison of (3a) and (3b) with (2) shows that

$$2E = MV_A + mV_a. \tag{4}$$

A reader familiar with elementary physics will note a divergence in the statement of equations (2), (3a), (3b). It is customary to assign negative signs to the three right-hand members, because the energy is identified with the mechanical work required to separate the two particles to an infinite distance. These considerations are not of significance in the present discussion.

When instead of only two particles we have many masses distributed through space, the above equations apply to each pair. The total potential at a point is the sum of the separate potentials. If the distribution of mass is confined to a plane surface, and if it may be regarded as continuous, the potential at any point C in the plane is

$$V_C = \int \frac{1}{r} \, DdS. \tag{5}$$

Here D is the *surface density* of mass over the infinitesimal element of area dS; r is the distance from that element to the point C; and the integration is extended to all areas of the plane where D is not zero.

Thus if mass is distributed in a known manner over a plane, D being known everywhere, equation (5) enables the potential to be computed at every point. The outcome of the computation can be presented on a map of the surface by the device of *contours of equipotential*. The familiar contours on a topographic map which represent altitude above sea level are precisely contours of equal gravitational potential.

It can be shown that the total resultant force of gravitation acting on unit mass at any point in the plane is directed at right angles to the equipotential contour there, and has the value

$$g = \frac{\partial V}{\partial n} \tag{6}$$

In this ratio of differentials, n is the distance measured along the normal

to the equipotential. Since the quantity g is the force per unit mass, it is, by Newton's second law of motion, the *acceleration* of any mass produced by the gravitational field at the said points. However we shall use it only as the *gradient* of the potential—deferring the question of actual motion.

3. *The Formal Laws of Demographic Gravitation*

A great variety of evidence has been accumulated which shows that the above equations have applications to the average interrelations of people. To make them applicable it is only necessary to substitute N, the *number of people* involved, wherever the quantity mass appears in the original equations.

More strictly, we replace mass by $N\mu$, where μ is the *molecular weight* of the sort of person considered. It is necessary to have a standard of this weight. (Actually, *molecular mass* is the appropriate term, notwithstanding the customary physical usage). Accordingly, that of the "average American" is taken as unity. Presumably the molecular weight of an Australian aborigine, for example, is on this scale much less than one.

Thus equation (1) becomes

$$F = \frac{G(N_1\mu_1)\ (N_2\mu_2)}{d^2}\ , \qquad (7)$$

when the N_1 people are at a distance d from the group N_2. The constant G is left for future determination: a suitable choice of other units can reduce it to unity. F is to be called the *demographic force*; what this means in terms of sociological data is left for examination further along. The physical straight-line distance often is what we use as d although an illustration in section 9 applies to a case where d in (7) must be otherwise interpreted

The demographic force of attraction between two groups N_1, N_2, of average Americans a distance d apart, at points 1 and 2, respectively, is therefore

$$F = \frac{N_1N_2}{d^2}\ , \qquad (8)$$

and acts along the line joining them.

Their *demographic energy* by virtue of the force field is

$$E = \frac{GN_1N_2}{d}\ . \qquad (9)$$

The *potentials of population* are

$$V_1 = \frac{GM_2}{d}; \; V_2 = \frac{GM_1}{d} . \qquad (10)$$

Also

$$2E = N_1V_1 + N_2V_2. \qquad (11)$$

Equation (5) is unchanged:

$$V = \int \frac{1}{r} \, DdS; \qquad (12)$$

but V now is potential of population, while D is the *density of population* familiar to demographers. When D is known over a plane the *equipotentials of population* can be computed.

Demography, strangely enough, has lacked a measure, like V, of the *influence of people at a distance*. Density cannot be such a measure, because it is a purely local quantity.

We shall see that demographic energy is proportional to economic wealth. (§ 8).

4. *Types of Application of Demographic Gravitation in Sociology*

W. J. Reilly's statement (1) (1929) of a "law of retail gravitation" seems to have been the first recognition of demographic gravitation. His expression is derivable from equation (1). It fitted his observations of the position of the point of equilibrium intermediate between two cities competing for the retail trade of the surrounding rural dwellers:

$$\frac{N_1}{d_1^2} = \frac{N_2}{d_2^2} , \qquad (13)$$

d_1 being the distance from the city of population N_1 to the said point of balance, and d_2 being the distance from the city N_2.

The concept of the potential of population was developed by Stewart (2), who published its application to the distribution of the residences of college undergraduates, etc.; and also maps of equipotentials for the United States and other areas.

G. K. Zipf (3) emphasized the usefulness of the formula $N_1 N_2/d$ as a determinant of various relations between pairs of cities—for example, the interchange of telephone calls.

There is no need further to recapitulate evidence already published, and we pass to a rather detailed study of potential of population as the determinant of a variety of demographic and economic quantities in the United States.

5. *Maps of Equipotentials in the United States, 1940*

Two maps of potential of population in the United States computed according to the Census of 1940 have been published (4). Table 0 lists the

TABLE 0
DATA FROM MAP OF U. S. POTENTIALS, 1940

State or Section	Potential V, persons/mi. 0000 omitted	Gradient, g Magnitude persons/mi.[a]	Gradient, g Direction ("uphill" toward)
NJ (except NYC, Phila)	59	3000	var.
NH (S)	35	2500	S
Vt (S)	34	2000	S
Va (N)	38	2000	N
RI	44	1750	W
Conn	51	1250	SW
Mass	45	1250	SW
NY (except NYC)	41	1000	SSE
Me (S)	30	1000	SSW
Vt (N)	26	1000	S
Del	45	800	N
Md	43	700	NE
NH (N)	25	700	S
Me (central)	25	700	SSW
Mich	32	500	SSE
Mo	28	450	E
Pa	45	450	E
Va (S)	34	380	NNE
Ohio (W)	40	350	E
Ia (E)	28	350	E
Ark (E)	27	350	NE
Ind	37	330	ENE
WVa	38	330	NNE
Wis	27	330	SE
Ohio (E)	42	330	SE
Miss (N)	26	310	NNE
Me (N)	17	290	SSW
NC	30	290	NNW
SC	27	290	NNW
Ga	26	280	N

Note: The arrangement is in order of decreasing gradient. One expects a fair degree of correlation between g and V, in view of equations (8), (6) and (10). It is impossible in such a table to duplicate all the information on a large-scale map. The values of V and g are only approximate. The direction of g may vary many degrees within a small area near a large city, and the value of V likewise changes sharply there. The gradient indicates in magnitude and direction the maximum rate of increase of potential with distance in a neighborhood.

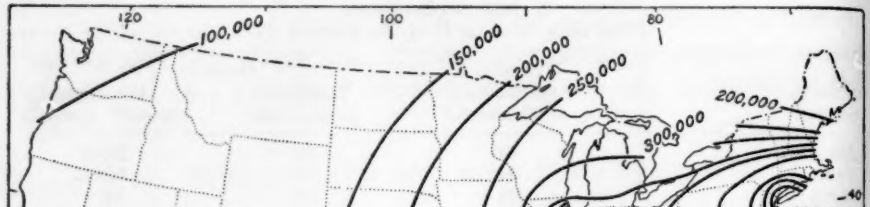
TABLE 0 (Continued)
DATA FROM MAP OF U. S. POTENTIALS, 1940

State or Section	Potential V, persons/mi. 0000 omitted	Gradient, g Magnitude persons/mi.[a]	Gradient, g Direction ("uphill" toward)
Ala (N)	27	280	NNE
Tenn	31	250	NNE
Minn	21	250	SE
Ky	33	240	NE
Ia (W)	23	240	ESE
Fla	18	230	NNW
NDak (SE)	16	220	ESE
Ala (S)	24	210	NNE
Ill (except Chicago)	33	200	E
SDak (SE)	17	200	ESE
Kans (E)	22	190	E
Ark (W)	23	180	NE
Tex (NE)	20	180	NE
La	22	180	NE
Miss (S)	23	170	NE
Okla	21	170	ENE
Neb	19	170	ESE
Kans (W)	18	170	E
SDak (NW)	14	130	ESE
Tex (SW)	14	100	ENE
Col	15	100	E
NM	13	100	ENE
Wy (E)	13	100	ESE
Mont (W)	11	100	E
NDak (NW)	13	70	ESE
Nev (W)	10	70	W
Nev (E)	10	70	E
Ida	11	70	E
U	12	67	ENE
Ariz	11	57	ENE
Wash	10	40	W
Calif (except cities and N)	13	37	WSW
Ore (except S)	10	33	WNW
Wy (W)	12	33	ESE
Mont (E)	13	30	ESE
Calif (N)	9	20	var.
Ore (S)	9	20	var.

general characteristics of the second, more accurate one, and disagrees in a few minor respects with Figure 0, which is from the first computation.

The table gives the approximate average of the potential in every state or section of a state, together with the magnitude and direction of the corresponding gradient g as defined by equation (6). For these maps the molecular weight μ has been taken as unity over the whole country.

Since potential is population divided by distance, it is expressed in units of *persons/per mile*. The gradient involves one more power of distance



in the denominator and therefore is in terms of the unit person/(mile squared.) To change a potential in persons/mile to the equivalent expression in persons/kilometer divide by 1.609, which is the number of kilometers in a mile. To change a gradient in persons/mile^2 to its equivalent in persons/kilometer^2 divide by (1.609).^{2}

The potential of population at a point may be regarded as a measure of the *proximity of people* to that point. In computing it we consider that every person makes a contribution which is less the farther away he lives. As we move from back-country rural areas toward a great city there is a rise in potential because of the concentration of people there. The gradient becomes steeper as the boundary of the city is approached. Inside the city the potential still continues to rise—all the way to the center, if the city is roughly circular. But nowhere does it reach values enormously greater than in rural areas nearby.

Thus every city is a local "peak" of potential, although Table 0 does not present sufficiently fine-grained data to show this. New York City is the major peak of the country, and in rural areas the general slope everywhere east of the Sierras is "downhill" away from New York. Even deep

in New York City the potential does not exceed by more than a factor of roughly 4 that existing at a farm 50 miles away. But the potential at such a New Jersey or Connecticut farm exceeds that in a good-sized Middle-Western city, because of the low "base" of potential on which the city stands. That is to say, you are closer to people of the whole United States on a farm in Hunterdon County, N. J., than you are at the center of Omaha, Neb.

Every general contour of potential east of the Sierras closes around New York; all the other cities are local peaks on the general downhill slope away from the number one metropolis. The major structure of the U. S. potentials has changed in form remarkably little in 100 years; New York City was already the principal peak in 1840 (5). Meanwhile average potentials in the East have risen by a factor of roughly 7.

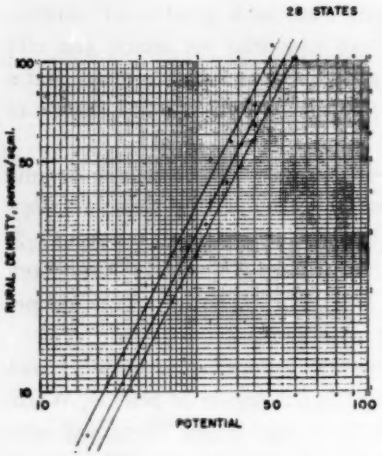
West of the Sierras there are two separate humps, each with its own closed contours around it. One hump centers in the region of Seattle, Washington, and the other in California. Each is as yet minor compared with the Eastern "massif", even if we allow for the rapid increase of West Coast population since 1940.

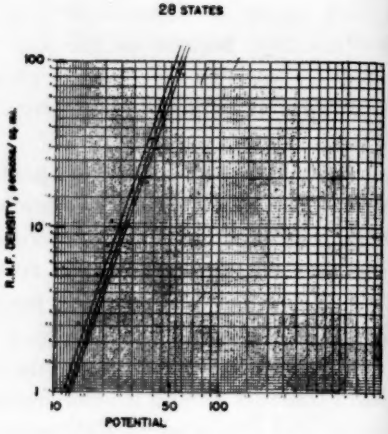
6. *Examination of Certain Averages of Demographic and Economic Statistics Along Equipotentials in Rural Areas*

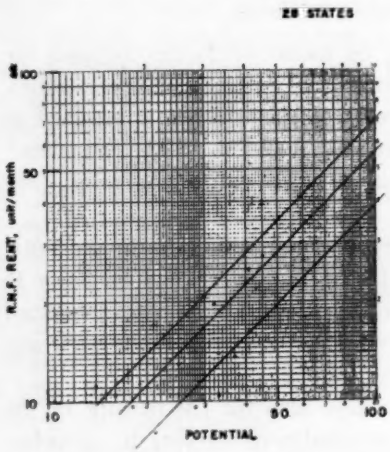
This section is presented principally by means of Tables 1-7 and the corresponding graphs. Because of the sharp local variations close to cities, the present study is confined to rural areas. Furthermore it is confined to 28 states from Texas to Maine, which we shall call the "Main Sequence." These states exhibit a considerable degree of statistical homogeneity. (See Table 1 for a list.)

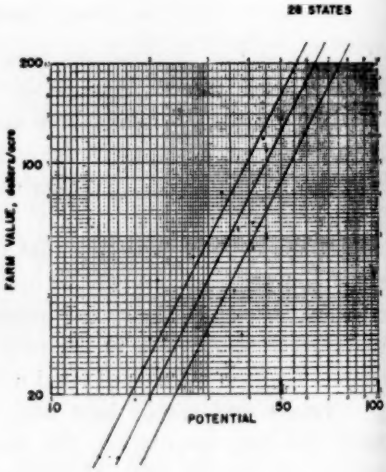
If the hypothesis is true that demographic gravitation is a fundamental social process, then a study of appropriate data should show a tendency to constant averages along any equipotential contour. This was confirmed in an early publication in the case of density of rural population (6), and later in the case of rents of rural non-farm dwelling units (7).

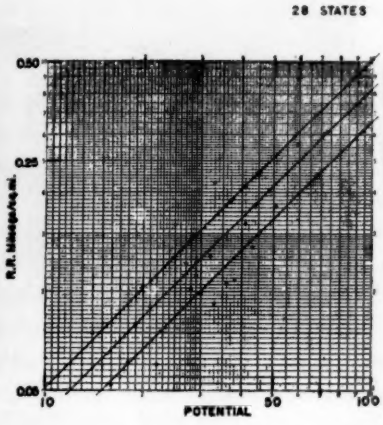
Tables and graphs here add confirmation also for the density of the rural non-farm population, the density of rural wage-earners in manufacturing, and for the value of farmland per acre. All of these quantities tend to be greater in states of high potential. When graphed on log-log paper against potential, they can be fitted by straight lines, which exhibit various degrees of steepness in their rise. All the data therefore are compatible with

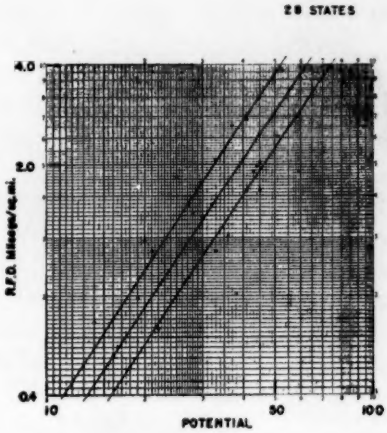

28 STATES
RURAL DENSITY, persons/sq.mi.
100
50
10
10
50
100
POTENTIAL

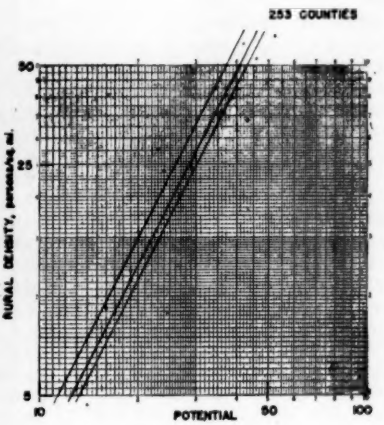

28 STATES
R.N.F. DENSITY, persons/sq.mi.
100
10
1
10
50
100
POTENTIAL

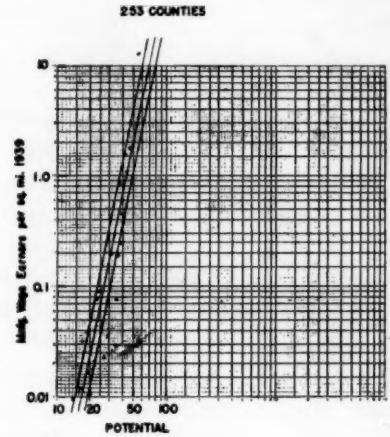

28 STATES
R.N.F. RENT, unit/month
100
50
10
10
50
100
POTENTIAL


28 STATES
FARM VALUE, dollars/acre
200
100
20
10
50
100
POTENTIAL


28 STATES
R.R. Mileage/sq. mi.
0.50
0.25
0.05
10
50
100
POTENTIAL


28 STATES
R.F.D. Mileage/sq. mi.
4.0
2.0
0.4
10
50
100
POTENTIAL


253 COUNTIES
RURAL DENSITY, persons/sq. mi.
50
25
5
10
50
100
POTENTIAL


253 COUNTIES
Mdfg. Wage Earners per sq. mi. 1939
10
1.0
0.1
0.01
10
20
50
100
POTENTIAL

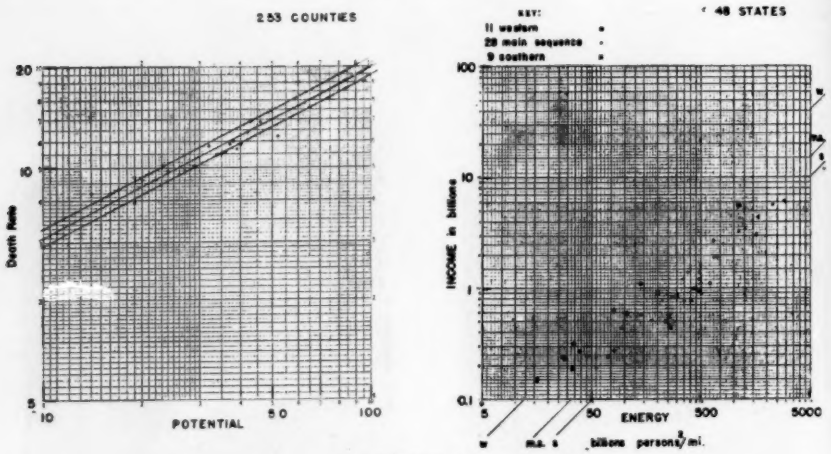


TABLE 1
VALUES OF POWERS OF THE POTENTIAL, V: 28 STATES 1940

State	V	$V^{3/2}$	V^2	V^3
NJ	59	453.185	3481	2054.
Conn	51	364.211	2601	1327.
Mass	45	301.869	2025	911.3
Penna	45	301.869	2025	911.3
Del	45	301.869	2025	911.3
RI	44	291.861	1936	851.8
Md	43	281.968	1849	795.1
NY	41	262.527	1681	689.2
O	41	262.527	1681	689.2
WVa	38	234.247	1444	548.7
Ind	37	225.064	1369	506.5
Va	36	216.000	1296	466.6
Ill	33	189.572	1089	359.4
Ky	33	189.572	1089	359.4
Mich	32	181.021	1024	327.7
Vt.	30	164.316	900	270.0
NH	29	156.171	841	243.9
Mo	28	148.162	784	219.5
Wis	27	140.297	729	196.8
Ia	25	125.000	625	156.3
Me	22	103.189	484	106.5
Minn	21	96.235	441	92.61
Okla	21	96.235	441	80.00
Kan	20	89.442	400	80.00
Neb	19	82.819	361	68.59
Tex	18	76.367	324	58.32
SDak	16	64.000	256	40.96
NDak	14	52.384	196	27.44

Note: If the desired unit of potential is the person/mile, multiply the V column by 10^4, the $V^{3/2}$ by 10^6, the V^2 by 10^8, and the V^3 by 10^{14}. The potentials were approximately estimated for rural areas, and the various powers are computed with unnecessary accuracy.

formulas involving proportionality to various powers of the potential. Rural death rates increase only as $V^{1/2}$, while the density of wage earners in manufacturing increases as V^5. In computing the various sorts of rural density the area of the cities was assumed to be negligible with respect to the states or counties.

The rise in the death rate in eastern states is a phenomenon already noted by W. G. Bowerman (8), but his suggestion seems very insecure that it is causally related to an associated decrease in the density of animal population.

One interesting statistic studied (Table 4) is the ratio of the number of miles of railway line in a state to the area of the state. This ratio turns out to be proportional to the first power of the potential. It measures the accessibility of the land to the railroads. If the railroads were laid out on a square grid, of k miles on a side, the ratio would equal $2/k$. For comparison, the grid of numbered streets and avenues in Manhattan exhibits a ratio of 27 miles of street per square mile of area. Information about the miles of railway is from Statistical Abstract of the United States (9).

Thus the higher the potential the greater the approximation to a straight-line communication between any two points. In low-potential regions what little rail traffic there is must often go by an indirect route.

Mathematical statisticians may object to the absence of least-square solutions to fit the assumed straight lines in the respective scatter-diagrams. The lines on each graph were drawn according to a slope which was chosen from the limited sequence 1/2, 1, 3/2, 2, 5/2, 3, ... The central line in each graph divides the plotted points evenly into two halves. The two outer lines divide the points of each half into equal quarters. Thus the distance apart of the two outer lines gives a measure of the spread. If its ratio to the length of the assembly on the logarithmic paper is small the fit may be considered a strong one.

The reason for restricting the slopes to the sequence mentioned is a theoretical one which relates to considerations of the "human gas," not dealt with in this paper. (These considerations really apply to the slopes only of the graphs of population-density, rent, and farmland value.)

Tables 2 and 5 refer to a list of 253 "rural counties" which lie in the 28 states of the Main Sequence. These counties were selected for zero or relatively small urban populations. This was in order to use certain over-all statistics—such as the number of wage-earners in manufacturing—without having to worry about the local distortion of potentials which is produced

TABLE 2
VALUES OF POWERS OF THE POTENTIAL, V; 253 COUNTIES, 1940

Median	V	$V^{1/2}$	V^2	V^3
a	52	7.21	2704	3802.
b	46	6.78	2116	2060.
c	43	6.56	1849	1470.
d	42	6.48	1764	1307.
e	40	6.32	1600	1024.
f	39	6.24	1521	902.2
g	38	6.16	1444	792.4
h	37	6.08	1369	693.4
i	36	6.00	1296	604.7
j	35	5.92	1225	525.2
k	34	5.83	1156	454.4
l	32	5.66	1024	335.5
m	29	5.39	841	205.1
n	27	5.20	729	143.5
o	24	4.90	576	79.63
p	23	4.80	529	64.36
q	22	4.69	484	51.54
r	20	4.47	400	32.00
s	19	4.36	361	24.76
t	19	4.36	361	24.76
u	17	4.12	289	14.20
v	16	4.00	256	10.49
w	14	3.74	196	5.378

Note: If the unit of potential is to be the person/mile, multiply the respective columns by 10 raised to the following powers: 4, 2, 8, 25. Tables 1 and 2 are for reference with respect to the computation of values of quantities in later tables.

by the influence of nearby cities. Such distortions cannot be allowed for on a map without great labor.

Since the total population of the 253 counties is much less than that of the 28 states, it is gratifying to find agreement within 12 per cent, for the coefficient of V^2 in the empirical rule for the density of rural population. For the 28 states (Table 3) we have the rural density averaging 0.0336 V^2, as compared with 0.0301 V^2 for the counties. (Of course the third figure is meaningless.)

Results for the 253 counties are smoothed by the device of plotting 23 medians, a, b, c, ... w, each of which represents 11 counties. With so small a sample of population as a single county, large fluctuations from the average would be expected if each were plotted.

Numerous additional statistics were examined for the counties. The suicide rate increases as the first power of the potential, while the birth rate declines and the median age increases. The excess of births over deaths decreases. The reader must remember that these are results for *rural*

TABLE 3
CORRELATIONS FOR 28 STATES, 1940

State	V	Rural Density Obs.	Rural Density Comp.	RNF Density Obs.	RNF Density Comp.	RNF Rent Obs.	RNF Rent Comp.
NJ	59	102.	117	84.0	115.4	29.98	32.80
Conn	51	112.	87	92.8	74.6	35.74	28.36
Mass	45	58.	68	45.9	51.2	39.07	25.02
Penna	45	74.	68	53.4	51.2	17.60	25.02
Del.	45	64.	68	41.1	51.2	27.17	25.02
RI	44	57.	65	47.2	47.9	24.96	24.46
Md	43	75.	62	50.2	44.7	21.83	23.91
NY	41	48.	56	33.4	38.7	24.95	22.80
O	41	56.	56	29.7	38.7	16.17	22.80
WVa	38	57.	49	34.8	30.8	11.93	21.13
Ind	37	43.	46	20.1	28.5	13.62	20.57
Va	36	43.	44	18.8	26.2	14.08	20.02
Ill	33	37.	37	20.0	20.2	13.85	18.35
Ky	33	50.	37	18.4	20.2	10.29	18.35
Mich	32	32.	34	16.5	18.4	19.59	17.80
Vt	30	26.	30	14.2	15.2	20.67	16.68
NH	29	23.	28	16.4	13.7	23.72	16.12
Mo	28	27.	26	10.2	12.3	9.60	15.67
Wis	27	27.	24	10.7	11.1	20.00	15.01
Ia	25	26.	21	9.5	8.78	12.97	13.90
Me	22	16.	16	10.8	5.99	20.77	12.23
Minn	21	18.	15	7.7	5.20	17.07	11.68
Okla	21	21.	15	5.4	4.50	8.13	11.68
Kan	20	13.	13	6.2	4.50	11.11	11.12
Neb	19	10.	12	4.0	3.85	11.30	10.56
Tex	18	13.	11	5.1	3.28	9.74	10.01
SDak	16	6.3	9	2.3	2.30	10.37	8.90
NDak	14	7.3	7	2.6	1.54	11.17	7.78

Note: Computed rural density, persons per square mile is 0.0336 V^3; R.N.F. Density is 0.000562 V^3. Observed values are from the U. S. Census. R.N.F. Rent is computed as 0.556 V, in dollars per month per dwelling unit.

areas, of density everywhere less than roughly 100 persons/mile.[2] In cities the densities are all above about 2,000 persons/mile,[2] rising to more than 250,000 in the densest census tract in Manhattan. The fall of the birth rate in cities is notorious, but the present study shows that most of the fall from the backwoods is evident in the high potential rural districts. Therefore population density is less suitable than potential as a determinant of vital statistics.

7. *Discussion of These Results*

These results make it evident that an intricate network of mutual correlations exists in the 28 states. If quantities $b, c, d, \ldots$ are functions of a, then b is also a function of c, and again of d, and so on. This makes it im-

possible to assert on merely statistical grounds that potential is the primary variable in the situations examined. Indeed later study may show that the *temperature* of the "human gas" may be of still greater significance. It is likely to be proportional to the first power of the potential.

TABLE 4
ADDITIONAL CORRELATIONS FOR 28 STATES, 1940

State	V	Farm Values		RR Mi/sq.mi.		RFD Mi/sq.mi.	
		Obs.	Comp.	Obs.	Comp.	Obs.	Comp.
NJ	59	121.54	174.05	.280	.246	1.179	2.343
Conn	51	135.41	130.05	.181	.213	1.502	1.883
Mass	45	109.40	101.25	.227	.188	1.047	1.561
Penna	45	59.22	101.25	.229	.188	1.272	1.561
Del	45	61.30	101.25	.149	.188	1.543	1.561
RI	44	118.67	96.80	.183	.183	1.235	1.509
Md	43	65.27	92.45	.138	.179	1.180	1.458
NY	41	55.16	84.05	.161	.171	1.037	1.357
O	41	65.91	84.05	.208	.171	1.706	1.357
WVa	38	30.29	72.20	.159	.158	.503	1.211
Ind	37	63.20	68.45	.190	.154	1.638	1.164
Va	36	41.05	64.80	.107	.150	.770	1.117
Ill	33	81.76	54.45	.214	.138	1.299	.9801
Ky	33	38.26	54.45	.092	.138	.682	.9801
Mich	32	50.59	51.20	.128	.133	.947	.9359
Vt	30	30.30	45.00	.099	.125	.870	.8495
NH	29	34.38	42.05	.111	.121	.703	.8074
Mo	28	31.87	39.20	.102	.117	.886	.7660
Wis	27	51.96	36.45	.121	.113	.936	.7253
Ia	25	78.79	31.25	.160	.104	1.147	.6463
Me	22	29.38	24.20	.060	.092	.397	.5335
Minn	21	44.26	22.05	.105	.088	.682	.4975
Okla	21	23.88	22.05	.090	.088	.640	.4975
Kan	20	29.51	20.00	.104	.083	.733	.4624
Neb	19	24.03	18.05	.079	.079	.490	.4282
Tex	18	18.81	16.20	.062	.075	.301	.3948
SDak	16	12.80	12.80	.052	.067	.330	.3309
NDak	14	12.92	9.80	.075	.058	.416	.2709

Note: Computed values per acre of farmland are 0.050 V^3, in dollars, if the unit of V is 10,000. Observed values are from the U. S. Census. Miles of railroad by states, and R.F.D. miles are from Statistical Abstract of the United States; the formulas are, respectively, 0.00413 V and 0.00517 $V^{3/2}$.

However it cannot be denied that the equipotential contours give a systematic picture of our national differentials. Even though the picture is valid only on the average, it ought to be presented in elementary geography courses, as well as in treatises devoted to advanced national planning.

The fact is very important that rural areas have a sociological structure which in the first rough approximation centers on New York City—and has so centered for 100 years. The Census Bureau's time-honored "center of

population," now in Indiana, is a socially meaningless, politically misleading mathematical whimsey.

Obviously this study of the Main Sequence should be extended to the remaining 20 states. So far this has been published only for the rural densities (10). The study of incomes presented in § 8 is a contribution to the same problem, although it does not deal specifically with the rural populations.

Another needed extension is to statistics for the cities in each of the three territories, namely the "main sequence" of 28 states, the Deep South, and the 11 states of the Far West. The smaller cities in the 28 states are distributed in conformity with the equipotentials: the number of cities 2500-5000, for example, per 10,000 square miles varies about as $V^{5/2}$. But the largest cities cannot be expected to follow a regular spatial pattern.

A good deal of data have already been accumulated for the cities, but inclusion here would unduly lengthen this paper. Annual urban taxes

TABLE 5
CORRELATIONS WITH POTENTIAL FOR 253 COUNTIES

Median	V	Rural Density		Density of Wage Earners		Death Rate	
		Obs.	Comp.	Obs.	Comp.	Obs.	Comp.
a	52	61.7	81.4	11.26	2.832	12.3	14.2
b	46	52.5	63.7	1.79	1.535	13.8	13.3
c	43	30.4	55.7	1.051	1.095	13.7	12.9
d	42	57.8	53.1	1.52	0.9737	12.8	12.7
e	40	42.2	48.2	0.38	0.7629	11.8	12.4
f	39	39.9	45.8	0.46	0.6721	11.3	12.3
g	38	39.5	43.5	.289	0.5903	12.0	12.1
h	37	40.5	41.2	.85	0.5166	11.7	12.0
i	36	36.3	39.0	.19	0.4505	11.2	11.8
j	35	35.6	36.9	.077	0.3913	11.0	11.6
k	34	42.4	34.8	.029	0.3385	10.9	11.4
l	32	31.1	30.8	.200	0.2499	11.5	11.1
m	29	24.5	25.3	.036	0.1528	10.2	10.6
n	27	20.2	21.9	.023	.1069	10.0	10.2
o	24	23.8	17.3	.09	.0593	9.8	9.6
p	23	27.7	15.9	.077	.0479	10.1	9.4
q	22	17.9	14.6	.021	.0384	9.1	9.2
r	20	15.6	12.0	.025	.0238	9.1	8.8
s	19	11.9	10.9	.039	.0184	9.3	8.5
t	19	11.1	10.9	.017	.0184	7.9	8.5
u	17	8.9	8.7	.032	.0106	8.5	8.1
v	16	9.2	7.7	.012	.00782	8.4	8.0
w	14	4.7	5.9	.0097	.00401	8.4	7.4

Note: The formula of rural density, 1940, is 0.0301 V^2; density of wage earners in manufacturing industries is $7.45 \times 10^{-9}\ V^5$; death rate is 1.97 $V^{1/2}$. Observed values from U. S. Census, the death rate being the average of the two years, 1939-40.

per capita, for example, increase with the average total potential in a city (i.e., the rural base potential plus the city's own contribution). The suicide rate continues to increase with increasing potential in cities, but less rapidly than in rural areas.

8. The Relation of Demographic Energy to Income

The first suggestion that demographic energy is related to economic wealth came from the the fact that rents and land values tend to be dependent on the potential of population. When a potential map of the United States has been made for any census, the total demographic energy of the whole country, E_t, can be obtained from the formula

$$2E_t = \sum N_i V_i, \tag{14}$$

The summation is taken over the United States: N_i is the population of state or county, and V_i is its average potential there. This equation is a consequence of equation (11).

Furthermore the assumption is plausible that

$$2E_i = N_i V_i \tag{15}$$

where E_i is the demographic energy of the i-th state or county. Equation (15) is not an inevitable consequence of (14) and requires empirical justification.

Table 6 lists the demographic energies so computed for each of the 48 states in 1940, together with their average potentials, state by state, as estimated from the recently computed map (which is a refinement of the one shown in Figure 0.) In each state an additional correction was applied to V_i to take roughly into account the extra contributions made by the urban concentrations to their own potentials.

These corrections were based on the empirical formula which relates the area of a city in 1940 to its population (11)

$$A = P^{3/4}/357, \tag{16}$$

A being the area in square miles and P the population.

If a city is assumed to be roughly circular the radius computed from this area for a particular city, when divided into the city's population, gives roughly the potential at the city limits. The average potential inside the city may be twice as great as this. Full discussion is reserved for a later publication.

TABLE 6

DISTRIBUTION AMONG THE 48 STATES OF INCOME TO INDIVIDUALS, 1940, COMPARED WITH THE DEMOGRAPHIC ENERGIES

	State	Average Potential	Demographic Energy (billions of units)	Income (billions of cents) Obs.	Comp.
(1)	NY	98.7	6,660	1,183	2,000
	Penna	57.2	2,830	623	850
	Ill	57.1	2,250	574	680
	O	48.0	1,650	445	500
	NJ	86.4	1,620	314	490
	Mich	46.6	1,225	343	370
	Mass	50.5	1,090	331	330
	Ind	41.3	707	186	210
	Tex	20.8	667	265	200
	Mo	33.6	636	191	190
	Ky	36.4	519	88	160
	Va	36.8	492	113	150
	Wis	30.9	486	162	150
	Conn	56.1	479	142	140
	Md	52.0	473	122	140
	Minn	26.8	374	142	112
	WVa	36.9	351	76	105
	Ia	26.7	339	123	102
	Okla	21.5	270	83	81
	Kan	24.4	220	76	66
	RI	50.5	180	51	54
	Neb	24.9	141	57	42
	Me	22.8	97	43	29
	NH	33.3	82	27	25
	Del	48.0	71	24	21
	SDak	17.3	56	24	18
	Vt.	30.4	55	19	17
	NDak	14.4	46	24	14
(2)	NC	32.4	578	113	116
	Tenn	32.8	478	93	96
	Ga	28.0	437	99	88
	Ala	26.6	405	76	81
	La	25.4	300	85	60
	Miss	23.8	260	44	52
	SC	26.8	255	55	51
	Ark	24.6	240	49	48
	Fla	21.2	201	90	40
(3)	Calif	31.6	1,090	561	905
	Wash	15.9	138	110	145
	Col	18.6	105	59	87
	Ore	14.4	78	64	65
	Utah	14.5	40	27	33
	Mont	12.3	34	32	28
	NM	12.7	34	19	28
	Ida	10.9	28	23	23
	Ariz	11.0	27	24	22
	Wy	12.9	16	15	13
	Nev	10.0	6	9	5

Note: The computed incomes in cents per year are found by multiplying the demographic energy (units of persons^2/mi.) by (1) 0.83, (2) 0.30, (3) 0.20, respectively. The potentials listed in this table are higher than in the previous tables because here the computations of the local "city peaks" are included. The observed incomes are from a tabulation by the Department of Commerce.

Figure 6-1 shows that the states divide into three groups as regards the proportionality of income to demographic energy: namely, the Main Sequence of 28 states, the Far West, including 11 states, and the Deep South, which strictly speaking comprises 8 states, because the ninth, Florida, in many respects, belongs with the Far West.

We have, letting E_1 represent the energy in persons^2/mile, I_1 the income in cents/year of a state (1940):

$$\begin{aligned} 28 \text{ states:} \quad & I_1 = 0.30\ E_1; \\ 11 \text{ states:} \quad & I_1 = 0.83\ E_1; \\ 8 \text{ states:} \quad & I_1 = 0.20\ E_1. \end{aligned}$$

One way of introducing into the theory the differences which appear in these three empirical formulas is to assume that the "molecular weight" of people in the Far West is about double that of people in the Main Sequence; while the molecular weight of negroes in the Deep South averages only 1/3.

It probably is significant that the study (12) of residences of undergraduates who attended Princeton, Yale, Harvard, and M.I.T. during the 1930's showed about the same discrepancies for the West. Princeton had 2.34 times as many students from the 11 states as are computed by the potential formula if the latter is calibrated to fit the 28 states.

If further investigation shows that differences in molecular weight really exist, it will be necessary to correct the potential map accordingly—lowering potentials a little in the South and raising them along the West Coast. The changes would be by factors less than the suggested deviations from unity of the weights, because the influence of the Main Sequence is important everywhere. Then all the tables in this paper, especially Table 6, would require slight revisions, based on the new map.

Since consideration of demographic energy suffices to provide an interesting spatial treatment of incomes in the United States, the obvious suggestion is to examine the relation of the two in time. The result is presented in Table 7, and shows a remarkable proportionality for 120 years.

Evidently the raw American dollar of income has been endowed with a sort of statistical inertia which has kept it stable, on the average, in ratio to the demographic unit of wealth, the person^2/mile. One can advance reasons why this might be so.

The long-term rise in per capita income (and in prices) is exhibited as a consequence of the increase in population and of the consequent increase in the number of demographic units represented by any assigned economic good—such as an acre of farmland.

TABLE 7
NATIONAL INCOME AS A FUNCTION OF DEMOGRAPHIC ENERGY, 1829-1939

Year	Energy persons²/mi.	Income cents/yr.	Income/Energy
1829	3.6×10^{11}	1.0×10^{11}	0.28
1839	6.1	1.6	0.26
1849	10.7	2.4	0.22
1859	20.	4.3	0.22
1869	31.	6.8	0.22
1879	47.	7.2	0.15
1889	70.	10.7	0.15
1899	102.	15.	0.15
1909	149.	26.	0.17
1919	192.	63.	0.33
1929	256.	79.	0.31
1931	264.	60.	0.23
1933	269.	45.	0.17
1935	275.	57.	0.21
1937	280.	69.	0.25
1939	285	69.	0.24
1940	288.	75.	0.26

Note: The incomes are in current dollars, uncorrected for price changes, and are from a tabulation by the Conference Board (*The Economic Almanac,* 1948, p. 352.) The influence of the business cycle is evident, especially when data for a series of consecutive years are examined. In booms the dollar quotation of the demographic unit rises, while it declines in deflations. The 1947 income of about 200 billion dollars gives an income/energy ratio of 0.67 cent per demographic unit, which is the most extreme inflation in the whole record. The demographic unit, the persons²/ mile, is the contribution to the national wealth made by a pair of average Americans who live one mile apart.

The ups and downs of the business cycle have been accompanied by a rise in the dollar quotation of the demographic unit during the boom phases, followed by an equal fall during the busts. We find the United States now in the most extreme inflation of the 128-year record. Economists can point to the aggressiveness of the labor unions, to the farm-parity law, and to our departure from the gold standard as factors which, even without further enormous "defense" spending, may have broken the old anchorage to the demographic unit. Borrowing, lending, and insurance cannot work well if the dollar ceases to represent an objective value.

9. *Additional Specific Applications and Suggestions*

The Cost Ascertainment Report of the postal service gave the length of the average haul of non-local mail in the United States in 1931 as 444 miles. This compares closely with the result of a computation which assumes that the number of letters N_1 people write in a given time to N_2 people is kN_1N_2/r, r being the distance between them; k is supposed to be a constant

throughout the country. In the notation of calculus, the number of letters written by dq people who live in a certain place in the United States is $dq\int kdp/r$, where the integral is taken for all the people in the country. And the total number of letters written is

$$L = \int dq \int kdp/r = 2kE. \tag{17}$$

Here

$$2E = \int dq \int dp/r, \tag{18}$$

where the integrals are taken throughout the country; E is the demographic energy, since $\int dp/r$ is the whole potential acting on the element of population dq.

The total miles traveled by all the letters written is

$$T = \int dq \int (k\ dp/r)r = kP^2, \tag{19}$$

where

$$P = \int dp;$$

so P is the total population of the country.

Evidently the average length of haul is

$$h = \frac{P^2}{2E}. \tag{20}$$

In 1930 *P* was 124 million people, and *2E*, without including the extra contribution of the city peaks, can be estimated as 38,000 billion persons²/mile. Then (20) gives $h = 430$ miles, in satisfactory agreement with the observed value of 444 miles.

It is worth noting that since the Census of 1790 the computed value of *h* has increased less than common opinion about the expansion of the country would suggest. In 1790 this average distance of people from people in the United States was roughly 200 miles.

If it is wished to include the practically zero length of haul of local mail in the average for 1930, we add in the computation a considerable positive correction to E, which represents the extra energy of the urban concentrations. Equations (17) - (20) may be expected to apply to a variety of person-to-person interchanges resembling mail. Further testing would be in order.

The concepts of potential and energy are applicable for solving readily, to a first rough approximation, such a question as, Would a bridge over a river at a given point, or a certain highway tunnel through a long moun-

tain ridge, be economically justified? In these cases, the straight-line physical distance is not the one to use in computing the initial potentials, because the topographical barrier forces communications to take roundabout routes. Examination of the map would show what distances it is reasonable to use in equation (10) before and after the new facility is constructed. The expected increase in potential in each area is multiplied into the size of the population affected; the sum of the products is twice the increase in wealth in demographic units.

For example suppose two cities of 10,000 and 15,000 people, respectively, lie on opposite banks of a river a mile wide which has neither a bridge nor a ferry for a hundred miles. If the average distance apart of the people in the two cities is 2 miles, the gain in demographic energy provided by the bridge, from the improvement in local connectivity only, will be

$$G = (10{,}000)\ (15{,}000)/2 \quad \text{persons}^2/\text{mile},$$

assuming unit molecular weights. This is 75 million demographic units. At the inflated 1947 monetary quotation (see footnote, Table 7) of about 2/3 cent/year, this gain, after the new equilibrium became established, might produce an increase of 500,000 dollars (1947 variety) in local incomes per year.

Consequently an expenditure of perhaps 1,000,000 dollars to build the bridge would seem justified. However, the officials would know that only a fraction of the 500,000 dollars per year would operate to maintain an increased value of the real estate in their two cities. The remainder would escape their taxation.

With respect to the relation of real estate value to demographic energy in small cities, the residential rental data compiled in the 1940 Census are important. A quick survey shows that the rent per month per dwelling unit in cities of the 2,500 - 5,000 size class was about five dollars greater than the rural non-farm rent in the respective counties. Allowing 4 persons to a dwelling unit, and an average population of 3,500, we find that such an urban concentration supported an increased rental of about 50,000 dollars per year, as compared with what the 3,500 people would have paid at the rural non-farm rate of the neighborhood.

Equation (16) suggests that the radius of a city of 3,500 might be 2/3 mile. The potential of population at the edge would be nearly that which would result if all the people lived at the central point; namely, 5,000 persons/mile; and the average potential within the city might be twice

this. Since, by equation (14), energy is half the product of population by average potential, the extra demographic energy associated with the formation of the little city is, roughly, half 10,000 times 3,500, or 18 million persons^2/mile. At the 1940 quotation of 0.26 cent/year, this energy corresponds to an increase of income of 47,000 dollars a year above what the same people would have been expected to have if they lived as rural nonfarm population in the same general vicinity of the United States and were not concentrated in their city. Evidently, all of this extra income would be needed to meet the urban increase in residential rent.

This result does not seem reasonable, because only a fraction of income normally is spent for rent. Doubtless when people live close enough together to form a city each exerts on his immediate neighbors a demographic force of *cohesion,* which adds to that of demographic gravitation and is associated with additional economic value. In order to use the same sewer and water lines, etc., people must live very close together. If they spread out a little their mutual energy of gravitation does not lessen much, but the required extensions of graded streets, curbs, sidewalks, gas mains, electric wires, postmen's routes, and the like, are costly. These urban improvements must be a factor in the increase of urban rent.

When gas molecules come close enough, their cohesion binds them together and they form a liquid. Investigation shows that the rural population is analogous to a gas. The suggestion that a city may be looked upon as a drop of liquid is worth following in future work.

This paper has outlined a good deal of material which points to the validity of the energy and potential equations of demographic gravitation. Work also has been done which illustrates the applicability of the third form of the law of demographic gravitation, namely, equation (6) for the gradient (slope) of potential. East of the Sierra Mountains, as Table 0 indicates, every city except New York itself is a local peak on the general downhill slope of potential of population away from New York. On topographic contour maps a mountain peak is shown by closed contours of potential (elevation) around it. Likewise, closed contours of potential of population extend over a sizeable area around a large city, and over a small area around a small one. The outermost such closed contour marks the limit of the region where land values would be expected to increase toward the city, and where the city in other ways may be exercising the dominant influence.

From the mathematics of potential theory it is not hard to show that

this area is roughly equal to P/g, where P is the city's population, and g is the general slope of potential in that section of the country. Where g is especially large a small city or a village has a very small area of influence. Indeed if P is small enough in ratio to the gradient, g, the village has no zone of its own at all, and we expect it then to show signs of being torn apart by the "tidal" action of the rest of the nation—like a planet too close to the sun.

Within the limits of a great metropolitan district, the gradient is especially large, and it is fairly large in all the sections listed near the beginning of Table 0. It is a fact, which the reader may verify by inspection of such sections, that the smaller settlements often tend to be ragged in outline and to lack the individual identity and regular form which they assume where g is small. Space is lacking here to give a full discussion, and work is being continued; but this is another confirmation of the existence of demographic gravitation and of the authenticity of the equations presented in this discussion.

The studies of Section 6 also are being continued. One objective is to draw up a list of "normal" counties, for which the statistics fall close to the central lines of the different graphs. "Hot" counties, of superior-to-average economic conditions, and "cold" ones lower than average, are also of interest.

In Europe, rural densities in the 1930's resembled those in the United States in varying as the square of the potential of population (13). The lack of homogeneity would make some of the statistics represented in Section 6 difficult to set up in Europe. If we assume a molecular weight of unity, equal to that of the average American, the demographic energy of Europe works out as about 10 times that of the United States. A comparison with American activity and productivity indicates that Europe in the 1930's excelled the United States by a factor of less than 2.

There are many quantitative peacetime statistics which show that the magnitude of the measurable objective influences of Europe and other continents on the United States is a small fraction of the magnitude of the relations of our own citizens with one another. For example, the value of imports per year from all the world has been only about 6 per cent of our national income, over a long period. Distance alone does not account for so small an interchange; our isolation is greater than the width of the oceans would suggest.

There is of course plenty of evidence that the stringent national fron-

tiers and cultural differences weaken the mutual relationships of Europeans among themselves. In 1938 the Netherlands post office handled 320 million letters of internal origin and destination, but the foreign correspondence amounted to only 67 million (14). With 8 million Dutchmen in Europe's 500 million people, the international correspondence would have greatly exceeded the domestic if equations (17) - (20) applied as they do in the United States.

We might take this sort of thing as evidence that frontiers can produce the equivalent of a large increase in all the international distances, reducing the energies and potentials accordingly. Again more study is required. It might be mentioned that over a certain period 10 times fewer Canadians and 25 times fewer Mexicans came as undergraduates to Princeton University than would have been expected from the potentials of population. But against this must be set in Europe the fact that no marked distortion in the relation of rural density to potential seems to be produced by the frontiers.

No doubt certain relations are sensitive to cultural differences while others are not. In a first study we can afford to omit the sensitive ones. And also we are justified in concentrating upon relatively simple and undisturbed conditions within the United States. Thorough understanding of these must precede the refinements necessary to incorporate into the theory all the diversifications of a region so rich in and so vexed with demographic parameters as Europe.

As a working hypothesis, demographic energy may be interpreted as the *number of human relations per unit time*. We may think of a relation between a pair of people not as a static thing, like a string connecting them, but as an impulse which happens, like a wave along the string. The *accumulating total* of such happenings is the integral of the energy with respect to the time, and would seem to resemble *action* in physics.

Relations of people to one another require more than people to support them: they require also natural resources and technological facilities. How these two essentials are to be represented in formulas is not yet clear. They may have something to do with the molecular weight, which is the *demographic mass per capita*.

In physics mass is looked upon as interconvertible with energy. Mass is proportional to the *constitutional energy* of matter. This was first foreshadowed in equations published by J. J. Thompson about 1880, and then vaguely revealed in the late 90's in phenomena of spontaneous radioactivity.

In 1906 Einstein made the connection explicit, with his famous equation: energy equals mass times the square of the speed of light. But more than thirty years elapsed before uranium fission was discovered, and it is only months since a cyclotron transformed energy into mesons.

It may be that sociologists face problems resembling those which engage physics's newest phases. If the maximation of demographic energy or mass is set as a proper social goal, then what part must the freedom of the individual play? Can the sum of human relations represented by $(N_1\mu_1)\ (N_2\mu_2)/d$ be increased if instead of being permitted to occur spontaneously between pairs of persons the relations are required to be channelled through a chain of social command? Can an individual by taking thought add a unit to his demographic stature? Can society do this for him? Were the prophets right in insisting that every increase comes as a gift of spiritual grace from a Power above mankind?

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"CONSCIOUSNESS OF KIND" IN A COLLEGE POPULATION

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This paper reports on some of the conditions found to be associated with friendship choices in a small Eastern women's college in 1943. The study was designed to determine which, if any, of certain objectively determinable factors were associated to a greater degree than pure chance with friendship choices. More generally stated, the purpose was to determine the strength of in-group cohesion and the relative degrees of social distance between in-groups and particular out-groups as differentiated by certain selected conventional criteria or classifications determinable from the college records.

(a) *Method.*

The basic data on friendship choices were secured from the answers to the following question: "If it were possible for you to keep in touch with only three students after you leave college, which three would you choose?" Answers were secured from all except one student, a total of 253, (1) by a mimeographed request, which brought over 80% returns, (2) by a mimeographed follow-up, which yielded an additional 8%, and (3) by personal interview of the remaining 12%. The failure of this last group to respond to the written requests appears to have been due to neglect and indifference rather than any objection to answering the question.

The factors selected for testing as to whether they were associated with the choice of friends to a greater degree than chance were as follows:

(1)—Year in college
(2)—Major scholastic interest
(3)—Common domicile and geographic proximity between houses on campus
(4)—Scholastic standing as determined by:
  (a)—Rating of high school record by college Director of Admissions
  (b)—Standing on American Council Psychological Examination (taken by all entering freshmen)

*The data on the college population was assembled by Elizabeth Herriott of Bennington College, to whom acknowledgements are due.

(5)—Socio-economic status as determined by:
(a)—Father's occupation
(b)—Amount of tuition paid (reduced or full)
(c)—Whether student engages in part time remunerative work while at college.

With these data and the students' choice at hand, the analysis required the classification of all participants according to each of the above categories; and the tabulation of the choices to show the number of choices which each group, classified according to the above categories and regarding each as an in-group, gave to (a) their own group and (b) to outside groups. The analysis proceeded with the computation of an index indicating the strength of the tendency toward in-group or out-group choices in relation to the selections that could be expected from pure chance. For this we used the in-group preference index developed by Criswell (4). The Chi-square technique was also applied to each of the tables, testing the null hypothesis (i.e. that none of the above factors were significantly asociated with the choice of friends), and thus securing corroboration of the results obtained by the application of the Criswell technique.

The Criswell index consists of securing for each sub-group (a) the actual ratio between in-group and out-group choices and (b) dividing this ratio by the expected (chance) ratio.[1] The basic formulas for the *expected* ratios are as follows:

Let a = the number of individuals in any sub-group.
t = total number of choices by any sub-group.
n = total number of individuals in whole population tested.
E = expected ratio between in-group and out-group choices.

Assume that the population consists of two sub-groups 1 and 2 making t_1 and t_2 choices respectively. Then

(1) $\dfrac{t_1(a_1 - 1)}{n - 1}$ = Number of expected *in-group* choices by sub-group 1

and

(2) $\dfrac{t_1(n - a_1)}{n - 1}$ = Number of expected *out-group* choices by sub-group 1.

[1]Since expected choices are determined by the size of each group in the population, one can also express the Criswell index as a ratio of per capita incoming choices over per capita outgoing choices. As a forthcoming paper by Paul Lazarsfeld will show, this interpretation permits a number of further generalizations which indicate that the logarithm of the Criswell index would probably be preferable for general purposes in the kind of study here under consideration.

Dividing the first expression by the second, the expected ratio between in-group and out-group choices for sub-group 1 is

$$(3)\quad \frac{a_1 - 1}{n - a_1} = E.$$

The index of self-preference (for their own group as against the total population minus their own group) then becomes:

$$(4)\quad \frac{\text{Observed No. of in-group choices} \;/\; \text{Observed No. of out-group choices}}{E} = I_g. \text{ (General Index)}$$

An index greater than 1.00 indicates a preference for their own group; an index of 1.00 indicates complete indifference as between their own group and the rest of the population; and an index below 1.00 indicates a preference for the out-group rather than their own group. This index, I_g, we shall term the *general* index.

If it is desired to secure an index of in-group preference as against any *particular* out-group (rather than as against the total population minus their own group), the following computation may be used:

$$(5)\quad \frac{\text{Observed number of in-group choices} \;/\; \text{Observed number of choices given to particular out-group}}{\text{Population of in-group} \;/\; \text{Population of out-group}} = I_s.$$

I_s is termed the *specific* index. The interpretation of the numerical value of the index is the same as for the above case.

For example, in the college study reported below, it was found that 37 Dance-Drama majors (out of a population of 253) gave 43 of their 108 choices to members of their own group. That is,

$$a_1 = 37$$
$$t_1 = 108$$
$$n = 253$$

The number of expected in-group choices under these circumstances is $\frac{108\,(37-1)}{253-1} = \frac{3{,}888}{252} = 15.4$. The number of expected *out-group* choices under the same circumstances is $\frac{108\,(253-37)}{253-1} = \frac{23{,}328}{252} = 92.6$

Now the ratio of the expected in-group choices to the expected out-group choices is $\frac{15.4}{92.6} = .166$. Or, applying the equivalent and simplified formula (3) we have $\frac{37-1}{253-37} = \frac{36}{216} = .166$. The actual (observed) ratio of in-group choices was $\frac{43}{65} = .661$, and the index of in-group or self-preference is therefore $\frac{.661}{.166} = 3.98 = I_g$.

This figure is a measure of the degree to which the Dance-Drama majors prefer their own group (as indicated by choice of friends) to the rest of the student body.

We may also find a measure of the degree to which Dance-Drama majors prefer their own group to the Science majors, using formula (5). (See Table II)

$$\frac{\text{Observed No. of in-group choices} \,/\, \text{Observed No. of choices given to Science majors}}{\text{Population of in-group (Dance Drama)} \,/\, \text{Population of Science majors}} = \frac{43 \,/\, 6}{37 \,/\, 23} = 4.47 = I_s.$$

Thus, Dance-Drama students prefer their own group to Science students even more strongly than they prefer their own group to the whole student body (minus their own group). This index also may be regarded as an index of social distance or hostility toward particular out-groups.

(b) *The data and analysis.*

We present in this section (1) the tables indicating (a) the distribution of choices according to the various classifications, and (b) the general and specific indices for each of the classifications, and (2) a summary of the interpretations to be made from these tables.

From Table I, we conclude (1) that students of all classes prefer members of their own class to members of any other; and of all others taken together as an out-group (last column); (2) in general, of those choices given to other classes, more are given to the classes that are closer than to the more distant; (the exception is the sophomore preference of seniors to freshmen); and (3) choices tend to be given to the class next above, rather than below, one's own class.

The indices of Table II, In-group Preference Among College Majors, indicate that there is a definite tendency to choose within the group of

TABLE I
DISTRIBUTION OF CHOICES AND INDICES OF IN-GROUP PREFERENCE AMONG COLLEGE CLASSES

Class	*No.*	*Choices Given to: (Specific Indices, I)* Freshman		Sophomore		Junior		Senior		*Total*	*General Indices*
		N	*I*	*N*	*I*	*N*	*I*	*N*	*I*	*N*	
Freshman	103	207		49	2.67	15	6.30	9	8.48	280	4.16
Sophomore	65	32	5.48	111		31	2.59	16	4.05	190	4.11
Junior	47	10	13.15	28	2.95	60		29	1.67	127	4.01
Senior	38	4	30.43	16	4.81	26	2.14	45		91	5.68
Total	253	253		204		132		99		688	

Chi-square = 440.37. Critical value at .01 level = 21.66.

similar major academic interest. The Science division has the greatest degree of in-group preference, followed in order by Dance-Drama, Music, Literature, Art, and Social Studies.

Social Studies seems to have the least cohesiveness as a division. Their in-group preference in relation to all other groups is the lowest in value, and none of the other divisions seem to have either a strong preference or a decided non-preference for the Social Studies division. This would seem to be logical inasmuch as this division includes several areas of interest.

The Music and Science divisions mutually prefer each other, next to themselves, to any of the other divisions. These two divisions are, in turn, ranked lowest in order of preference by the other major divisions, except for the Literature division. The Literature division might be termed the most generally popular group. All of the specific indices of the other divisions in relation to literature rank it in the first or second place after themselves, except Science, which ranks literature fourth. The specific indices of the Art division are very interesting in that in each case (with the exception of the Social Studies division) the rank accorded *by* this division to another corresponds exactly with that accorded *to* them by the other division. That is, it seems always to be a case of mutual preference or non-preference.

Field of major interest might be considered to be more closely allied to personality factors than some of the other categories with which we have been dealing, and the temptation to embark upon theories as to the art-interest or science-interest type of personalities is correspondingly great. However, it is quite possible that the degree of attraction represented by these indices may be accounted for by the factor of propinquity, i.e., attendance at the same classes, rehearsals, etc. We shall return later to this

TABLE II

DISTRIBUTION OF CHOICES AND INDICES OF IN-GROUP PREFERENCE AMONG COLLEGE MAJORS

Major	*No.*	*Choices Given to: (Specific Indices)*														*Total*	*General Indices*
		SS		*S*		*A*		*L*		*DD*		*M*		*NO.*	*M*		
Soc. Sciences	64	59		12	1.76	34	1.57	19	1.55	24	1.42	12	2.30	10	.83	170	1.59
Science	23	14	3.76	19		6	7.97	4	6.61	7	4.36	13	1.90	3	2.48	66	4.25
Art	58	38	1.71	5	4.68	59		20	1.62	16	2.35	11	2.77	10	.92	159	2.02
Literature	32	19	2.20	5	3.02	20	1.90	21		6	4.05	10	1.96	2	2.95	83	2.41
Dance																	
Drama	37	21	3.52	6	4.47	17	3.95	12	3.11	43		8	4.36	1	10.46	108	3.98
Music	30	15	2.99	11	1.46	11	3.67	12	1.86	3	8.64	21		5	1.26	78	2.83
No Major	9	9	.14	3	.39	8	.16	1	.28		.24	3	.30			24	.00
Total	253	175		61		155		89		99		78		31		688	

Chi-square = 173.86. Critical value at .01 level = 44.31.

subject. In the meantime, Table III provides striking testimony of the influence of this factor of propinquity.

All of the specific indices in Table III are very large, by far the largest indices that occur in the whole study, indicating that residence in the same house is the factor most highly associated with the choice of friends. Propinquity in the sense of geographical proximity of the houses on the campus does not seem to have such great importance, however. The campus is divided into two distinct sides, the East and the West, with six student houses on each side. (The letter N in the tables represents not a house on the campus, but rather students who live off-campus.) From the indices it would seem that students within houses on the East side have a definite self-preference for their own house; but once outside the house they distribute their choices with little consciousness of their own side of the campus. Houses on the West side, with a lower mean of self-preference, distribute the majority of their outside-house choices within the West side. All of the specific indices are very large, however, indicating so much in-group preference among the residents of each house that any generalizations about the order of preference given outside the house is of relatively little significance.

TABLE IIIa
DISTRIBUTION OF CHOICES AMONG HOUSES ON CAMPUS

House	*No.*	*Choices Given to Members of House:*													*Total*
		A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*J*	*K*	*L*	*M*	*N*	
A	22	33	4	4	2	2	2	4	6	1					58
B	21	4	30	1	3		2		4	2		2	3	2	53
C	21	3	1	31	3	1	1	4	4	2		6	2	2	60
D	23	2	3	4	33		4	2	5	4	4	3	4		68
E	15	1	2	1	1	21	2	3	4		2	2	3	1	43
F	19	2	1	2	4	2	24	3	4		2	2		4	50
G	20	4	2	4	2	3	4	26	2	3	2	1	3		56
H	21	3	7	3	5	4	5	3	18		4	1	2	1	56
J	21	1	3	1		1		3	1	31	5	1	2	2	51
K	21	2	1	2	3	4		2	2	6	32	1	4		59
L	21		1	6	4	1	3	7	3	2	1	24	1	1	54
M	21	2	3	1	2		2	3	4	1	4	1	36		59
N	7			1	1	1	4		1	2	2	1	2	6	21
Total	253	57	58	61	63	40	53	60	58	54	58	45	62	19	688

Chi-square = 428.96. Critical value at the .01 level = 21.66.

The fourth category to be studied in terms of its influence upon the choice process is scholastic standing. Two measures of scholastic standing were used, the first consisting of a rating of the high school records by the college Director of Admissions and Student Personnel. This consists of the Director's total impression of the high school record of each girl as rated

TABLE III-b

Indices of Self Preference among the Twelve Houses on Campus

SPECIFIC INDEX IN RELATION TO HOUSE:

Chosen

House	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*J*	*K*	*L*	*M*	*N*
A	(14.66)	7.93	7.93	17.25	11.30	14.34	7.50	5.50	31.73				
B	7.86	(15.11)	30.00	10.95		13.63		7.50	15.00		15.00	10.00	5.00
C	10.82	31.00	(12.32)	11.31	22.14	28.18	7.38	7.75	15.50		5.16	15.50	5.16
D	15.86	10.09	7.56	(9.91)		6.81	14.33	6.05	7.56	7.56	10.09	7.56	
E	30.83	14.70	29.41	32.20	(16.44)	13.30	9.33	7.35		14.70	14.70	9.80	9.81
F	13.90	26.54	13.27	7.26	9.52	(12.14)	8.42	6.63		11.06	11.06		2.21
G	7.15	13.65	6.82	14.95	6.51	6.19	(10.69)	13.65	9.09	13.65	27.31	9.09	
H	6.28	2.57	6.00	3.94	3.21	3.27	5.71	(5.50)		4.50	18.00	9.00	6.00
J	32.49	10.33	31.00		22.14		9.83	31.00	(18.02)	6.20	31.00	15.50	5.16
K	16.77	32.00	16.00	11.67	5.71		15.23	16.00	5.33	(13.72)	32.00	8.00	
L		24.00	4.00	6.57	17.14	7.27	3.25	8.00	12.00	24.00	(9.30)	24.00	8.00
M	18.86	12.00	36.00	19.71		16.36	11.42	9.00	36.00	9.00	36.00	(18.13)	
N			18.01	19.73	12.87	4.07		18.01	9.00	9.00	18.01	9.00	(16.66)

( ) Indicates General Index 14.75 = Mean Preference Index for East (houses C, D, E, J, K, M)
12.00 = " " " " West (houses A, B, F, G, H, L, N)

on a three-point scale, i.e., low, average, and high. (This classification is perhaps not too reliable since it is based on two more or less subjective ratings, first, on the part of the high school principal; and second, on the part of the college Director of Admissions. The influence of favorable and unfavorable personality traits upon the judgment as to good or poor scholarship is probably considerable.)

In general, we find (Table IV) that students within these scholarship groups (a) prefer members of their own classification to those in other classification, with one exception. The specific indices for the Low and High groups show (b) that there is a slightly larger degree of preference for the members of the closer group than for the more distant. All of the differences, however, are too small to be statistically significant.

The other measure used in this section, the American Council Psychological Examination, is more a rating of scholastic aptitude and "general intelligence" than the scholastic achievement measured by the high school record rating. The score of each student on this examination is given as a percentile ranking computed on the basis of the national percentiles for the

TABLE IV
DISTRIBUTION OF CHOICES AND INDICES OF IN-GROUP PREFERENCE AMONG HIGH SCHOOL STANDING GROUPS

		Choices Given to: (Specific Indices)							*General*
Group	*No.*	*Low*		*Average*		*High*		*Total*	*Indices*
Low	27	9		33	1.05	30	1.35	72	1.23
Average	104	38	.84	123		128	1.12	289	1.07
High	122	29	1.31	126	1.16	172		327	1.19
Total	253	76		282		330		688	

Chi-square = 6.65 (not significant)

TABLE V
DISTRIBUTION OF CHOICES AND INDICES OF IN-GROUP PREFERENCE AMONG ACPE PERCENTILE GROUPS

		Choices Given to: (Specific Indices)								
Groups	*No.*	I %iles 10-39		II %iles 40-69		III %iles 70-99		*No Record*	*Total*	*General Indices*
%iles 10-39	26	8		35	.712	27	1.63	1	71	1.14
%iles 40-69	81	29	.807	73		120	1.07	3	225	1.03
%iles 70-99	143	29	1.48	117	1.14	237		2	385	1.24
No Record	3	1		2		4			7	
Total	253	67		227		388		6	688	

Chi-square = 17.38. Critical value at the .01 level = 13.277

same examination. For the purposes of this study these percentile ranks have been divided into three groups, i.e., percentiles 10-39, 40-69, and 70-99.

The tendencies which appeared in the distribution of choices among the high school scholastic groups seem to be substantiated only in part by these ACPE indices. As may be seen from Table V, both the general and specific indices show a great deal of variation. We must conclude that, as here measured, similar "mental" scores are not strongly associated with in-group preference, although most of the indices indicate preference for their own group. (The exception is the preference of Group II for Group I, which is corroborated by the preference of "Average" group for the "Low" group in Table IV.) Smucker (7, p. 124) reports a contrary finding in this respect.

TABLE VI
DISTRIBUTION OF CHOICES AND INDICES OF IN-GROUP PREFERENCE AMONG GROUPS CLASSIFIED BY FATHER'S OCCUPATION

		Choices Given to: (Specific Indices)											
Group	*No.*	*I*		*II*		*III*		*IV*		*V*		*No Record*	*Total*	*General Indices*
I	103	142		93	1.40	25	1.27	1	2.75	2	2.06	30	293	1.38
II	95	105	.95	92		14	1.59	4	.48			36	251	.97
III	23	23	.58	19	.64	3		1	.26	2	.19	9	57	.57
IV	2	1		2		1							4	0.00
V	3	1	34.48			4	1.92			1			6	25.00
No Record	27	34		31		9						3	77	
Total	253	306		237		56		6		5		78	688	

Chi-square = 9.55, this value being significant at the .05 level

As the student body under study is, as a whole, of a generally high socio-economic status, analysis of in-group choices on this basis was not expected to yield very striking results. For our purpose, three measures of socio-economic status were used. These were (1) the Goodenough-Anderson occupational classification, (2) whether the student received reduced tuition from the college, and (3) whether the student was a "self-help" student, i.e., earned money as a waitress in the college dining rooms, as an assistant in the library, etc.

The Goodenough-Anderson scale contains seven occupational groups. The occupations of the fathers of the students in this college fell into only the first five of these groups,[2] with a large majority of them being classified

[2]I—Professional; II—Semi-professional and managerial; III—Clerical, skilled trades, retail business; IV—Farmers; V—Semi-skilled occupations, minor clerical and minor businesses. Goodenough, Florence G. and Anderson, John E., *Experimental Child Study*, Century Co., 1931, Chap. 27, p. 237.

as Group I and II. This analysis in terms of father's occupation yields very little in the way of definite trends (Table VI). The indices of Groups IV and V must be considered very unreliable because of the small size of the groups, and the trends in direction of preference among the three middle groups seem too varied to admit of generalization. The highest and the lowest groups show the most in-group preference as determined by their general indices, and seem to have the largest degree of preference for the groups closest to them in status.

The indices calculated from the groups determined by absence or presence of reduced tuition show a greater degree of in-group preference on this basis and more consistent trends in the choices made outside these groups than do the indices dealing with occupational groups. The reduced tuition classification was handled in the following manner: Four groups were determined: (1) those students who received no reduced tuition during the college year 1942-43; (2) those students who received less than $400. This group was classified "Low"; (3) those who received between $400 and $600. This group is the "Average" group; and (4) those who received more than $600. This is the "High" group.

The indices from these data indicate that there is a tendency to choose within the group of similar economic status. (Table VII). The in-group

TABLE VII

DISTRIBUTION OF CHOICES AND INDICES OF IN-GROUP PREFERENCE AMONG GROUPS CLASSIFIED BY AMOUNT OF REDUCED TUITION RECEIVED

		Choices Given to: (Specific Indices)									
Group	*No.*	*Low*		*Average*		*High*		*None*		*No Record*	*Total*	*General Indices*
Low	17	5		11	.98	3	3.02	20	2.35	1	40	2.11
Average	37	11	.75	18		17	.88	55	1.42		101	1.30
High	31	7	1.33	12	1.69	17		44	1.99	4	84	1.87
None	160	28	1.16	57	1.24	47	1.26	305		5	442	1.30
No Rcd.	8	2						10		9	21	
Total	253	53		98		84		434		19	688	

Chi-square = 23.44. Critical value at the .01 level = 21.66.

preference of the students who received scholarships is a little higher than that of the "no scholarships" group. That there is a greater degree of in-group preference among the groups receiving reduced tuition is further indicated by the fact that all the specific indices of the reduced tuition groups are higher in relation to the "no scholarships" group than are the "none" group's specific indices in relation to each of the "scholarship" groups. There is also noticeable a tendency to prefer, after one's own group, the next

TABLE VIII
DISTRIBUTION OF CHOICES AND INDICES OF IN-GROUP PREFERENCE AMONG SELF-HELP AND NON-SELF-HELP STUDENTS

	Choices Given to:			
	No Self-help	*Self-help*	*Total*	
Group	*N*	*N*	*N*	*N*	*General Indices*
No Self-help	159	292	145	437	1.20
Self-help	94	141	110	251	1.31
Total	253	433	255	688	

Chi-square = 7.75. Critical value at the .01 level = 6.63.

closest group, and to have the least preference for the group most distant in economic status.

The "self-help" classification used only two categories: (1) a "no" group consisting of students who earned less than $25.00 in a term; and (2) the "yes" group consisting of students who earned more than that amount in one term. The in-group preference indices for these two groups support the findings stated above. That is, both groups show a slight in-group preference.

(c) *Conclusions.*

The entire population of a small college answered the question: "If, after leaving college, you could keep in touch with only three students now in college, which three would you choose?" The results indicate an always definite and in some respects a very strong tendency to name people belonging to one's own in-group as regards (a) common domicile, (b) college class, (c) major scholastic interest, and (d) socio-economic status. On the other hand, (e) scholastic standing, and "aptitude" as here measured showed little or no significant association with in-group preferences. The in-group indices were high with respect to each criterion approximately in the order mentioned above, common domicile being by far the most conspicuous in-group factor reflected in the indices.

Frequency of association is perhaps also the most important factor in the choices among the various years and majors. In the discussion of the major indices we noted that those divisions with the largest degree of necessary contact, i.e. Drama-Dance, Science, and Music, in which most of the work is done in close association with the other members of the division, had the largest degrees of in-group preference.

The high degree of in-group preference of the different classes must also be attributed, in part at least, to such association, i.e. attendance at the same

classes. Another factor in the intra-class choices may be that as each class enters college they find a community whose friendship groups are to a large extent already set, and are therefore forced to make friends among their own class.

The question will arise as to whether the observed in-group preferences *result from* the choice of association or whether friendships already formed on some other basis cause students to choose a house, major, classes, etc., *in order* to associate more closely with the previously preferred members of the group. It is impossible to resolve this completely on the basis of the data we have at hand, save to point out that on this particular college campus, a majority of students remain in the house in which they tend to make friends because of the house association, rather than move to be with friends chosen on some other basis.

There are strong presumptive grounds for believing that propinquity is the prior or dominant factor which largely determines the positive in-group indices found also among the other factors. That is, the accidents of propinquity determine, first of all, the universe from which choices are possible. The nature of college and class organization will automatically throw together with greater frequency the members of a particular class, and of a particular academic major. As for the in-group value of a common scholastic standing, the measures of this factor in the present study are admittedly crude and the indices secured were of negligible size. Socio-economic status, even in a highly democratic student-body, again, would be likely to find some expression in the fact that students of common socio-economic status, quite aside from any deliberate or conscious choice or discrimination on this basis, would be thrown together disproportionately more frequently by the fact that larger numbers of each status group would be engaged in common employment, amusements, etc.

The above conclusions are further supported by a study now under way[3] which suggests that persons *disliked* tend to be chosen more frequently

[3]Some resistance was encountered toward the questions regarding persons disliked as prospective roommates. Some of the comments by people who refused to answer these questions are very revealing regarding the inhibitory effect of current mores on objectivity toward discussions of negative interpersonal relations. One girl (home economics) after answering all the questions conscientiously added these comments:

> "I have a very uneasy feeling about this whole questionnaire, just filling it out in the 'interest of science' does not seem to justify it to me—I really don't know why I'm doing it. This analysis of friends is entirely contrary to what I have been taught at home and at church. I don't like to admit even to myself that there are people I definitely dislike—much less set their names down for other people to see.

than by chance from the same in-groups as the persons *liked*. That is, our interpersonal relations are in essence in-group relations and any attempt to pursue further the factors which are associated with likes and dislikes *with exposure or contacts held constant* should be conducted, to begin with, on the most intimate in-groups which nevertheless allows a range of preference. In the last analysis, of course, and to use the most extreme definition, an in-group may be said to consist *only* of persons *mutually desiring each other's association*, and we are interested in determining precisely why one group of individuals rather than another are in fact found so associated. The answer must clearly be sought by more refined methods and under conditions permitting control especially of the factor of propinquity. From this point of view the definition of in-group by classifications such as class, scholastic major, etc., may be said to be arbitrary and based on other than the true psychological or sociological criterion of group membership, namely, a conscious attraction as against non-members. Of course, it is still a permissable and valuable inquiry to determine to what degree in-group feeling exists among the members of the conventional and convenient classifications of people. It remains a highly important scientific objective to determine (a) *what types of classification and associations* of people are likely to be associated with strong in-group feelings, and *vice versa*, and (b) what are the general sociological processes operating to produce the observed results. For example, can it be shown that the phenomenon called attraction is merely

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By far the greatest number of girls in this hall are quite agreeable to me and I'm sorry there isn't more room for 'likes'."

Another girl (music) returned the blank unfilled with the following comment:

"I'm sorry that I cannot cooperate by filling out this questionnaire, but for several reasons, I do not feel right in doing so. I think it very unfair to deliberately dig out of my mind three people that I don't like especially. No matter whether they will know or not, I will know who they are, and would always feel as if I were accusing them unjustly and without good reason."

This remark indicates that mere anonymity is not the sole consideration in the difficulty of securing negative choices. Smucker's suggestion (**8**, p. 383) that the objection can be met by establishing confidence in anonymity is therefore doubtful, and it is possible that a considerable number of the one-third of his total who made no negative choices abstained for reasons explicitly stated by some of our respondents as recorded above.

Smucker (**7**) reports that in his study three times as many positive as negative choices were made (p. 123). One-third of those who participated in his study made no negative choices (p. 124). The comparable figures for the study now under way are: Approximately one-seventh of those who participated made no negative choices (31 out of 230).

a special case of conditioning and learning in approximately the following sequence: We *learn* to react to the people with whom we have contact; it therefore becomes *easier* to interact with them than with people with whom we have fewer or less intense contact; the *easier* interactions are the more *pleasant*; we call people with whom it is easy and pleasant to interact our "friends", "in-group", etc.? On the other hand, if it can be shown that the interaction known as *repulsion* results not merely from infrequency of exposure or necessity to interact but from greater difficulty of learning to interact with facility between some people due to intrinsic differences in their behavior traits, interests, and emotional patterns, etc., then the attempt to break down group prejudices, discrimination, etc., by merely throwing the groups together and forcing them to interact can only aggravate the difficulty. (5, p. 314).

The methods here employed are, of course, applicable to group cleavages of any kind—friendship (2), religious and ethnic (3), status (5), racial, occupational, political (6), or what not. Further light on the questions raised will be secured perhaps from intensive analysis, not here included, of individual sociograms.[4] More comprehensive and intensive study of the factors associated with in-group and out-group attractions and repulsions should yield reliable prediction principles of this basic social phenomenon.

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SOCIAL CHANGE AMONG YEMENITE JEWS SETTLED IN JERUSALEM*

A Quantitative Study in Dynamics and Correlations Among Culture Traits

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I. Introduction

1. *Purposes of This Study.*

The purpose of this study is to measure the change over a period of seventy years of seven culture traits among a selected group of Yemenite Jews who emigrated from Yemen from 1876 to 1946 and settled in Jerusalem.

Coming to Palestine Yemenite Jews came in contact with an environment quite different from the one to which they were accustomed. They shifted from a culture of primary relationship, where family and church are the only institutions and where control is exercised through customs, to the complex culture of western groups, built mainly of secondary relationship. Such a change is well known to sociologists and has been studied among many groups.

No attempt, however, will be made here to give a "panoramic", all embracing, description of the group studied, but rather an attempt will be made to describe the change, or at least some aspects of it, in the minimum possible number of scientific categories. As Thurstone has said (Ref. 13, p. 46) "From the viewpoint of immediate experience scientific description is necessarily incomplete."

According to Dodd's S-system (Ref. 1) all social phenomena may be adequately stated in terms of Population, Space, Time, and Indicators.

In our study the Population does not change, at least theoretically, as either the settlers or their descendants are studied; space also does not change as settlers are studied from the moment they reach Jerusalem onward. The only variables then are Indicators (the seven culture traits) and Time (seventy years).

The hypothesis is made and tested that social and economic conditions

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of Jews in Yemen did not change during the period studied. This fact made it possible to keep the final point (time of measurement) fixed, while the starting point (time of immigration) moved from 1876 to 1946. The interest of the situation is that it permits the objective measurement of changes over a long period, which is, in ordinary cases, practically impossible.

The time series obtained are fitted to reversed logarithmic curves. Possible future trend of change and some related concepts as velocity and celeration are disclosed. The existence of logistic surges of change are indicated.

The correlation between every pair of traits is calculated and the correlation matrix factorized. Seven cultural traits are cleanly reduced to three factors. Results of factor analysis and their possible significance are also examined.

2. *Methodological Observations.*

One of the fundamental problems in any scientific investigation is how to isolate the effects of each one of the factors that are presumed to influence a given situation. The best method to this end is the experimental method. However, its application to social sciences is exceedingly difficult as it requires a complete control of the subject matter.

On the other hand, the statistical method, in order to explain completely a given situation, requires:

(a) The measurement of all relevant factors;

(b) A sample large enough to allow for the statistical analysis of each factor in turn. As even in the relatively simpler social situations the number of relevant factors is very great (and frequently factors are not easily measurable), the pure application of this method would call, in the best case, for a very large sample.

The studies of Chapin (Ref. 4, 5, 6) and Dodd (Ref. 7)* have, however, shown that a "compromise" technique between the two pure methods is possible and useful. Briefly this technique may be described as follows:

(a) Choice of small, relatively simple situations.

(b) Reduction of sample in order to eliminate the largest possible number of factors.

(c) Measurement and statistical analysis of remaining factors.

The philosophical and theoretical aspects of such an approach to the

*Dodd's story is, however, nearer to pure experimental method.

study of social phenomena have been adequately treated by Lundberg, Dodd and others (Ref. 1, 2, 3). The writer refrains therefore from discussing them here. He merely accepts this frame of reference without denying that other approaches might be also conducive to useful results.

3. *Jews of Yemen and Their Settlement in Jerusalem.*

The Yemenite Jews who settled in Palestine represent a group well suited to an intensive sociological research, for the following reasons:

(a) Immigration of Yemenite Jews into Palestine began in the second half of the 19th century and continued almost without interruptions up to 1944-45.

(b) Yemenite Jews are a well defined group, who for many centuries lived in comparative isolation. Before immigration to Palestine they had very little contact with fellow Jews. They also did not mix with the Moslem population of Yemen. In their physical aspect they differ considerably from other Jews, even Jews from other Middle East countries. Blood examination of Yemenite Jews both in Palestine and in Yemen suggests that they are a comparatively "pure" group. Although the influence of these biological values on social phenomena is quite unknown, it may be permissible to presume that biologically homogeneous groups will in any event not behave socially in a less homogeneous way than any other group.

(c) Finally there is evidence that social and economic conditions of Jews in Yemen did not change during the whole period studied. In other words, at the time of immigration the first settlers were in the same conditions as immigrants who reached Palestine only a few years ago. As this is a point of major importance in this study it will be treated with some detail.

* * *

To prove the assumption that no major changes happened in the situation of Jews in Yemen during the period studied, through the analysis of statistical data, is impossible for the simple reason that no statistical data are available for Yemen, except some rough estimates of area and population.

On the other hand, what Yemenite Jews are undergoing in Palestine is—as will be seen later—a process of westernization. The accounts of travelers who visited Yemen in the period from 1870 until the present agree that in Yemen there is no trace of western influence. A more detailed review of the literature will be found in the microfilm edition of this paper.

Moreover when the families of the sample were interviewed, data were

also collected about the occupational status of father and grandfather of the heads of families[1] in order to study heredity of occupation among Yemenite Jews both in Yemen and in Palestine.

It was found that occupation was hereditary in the following percentage of cases:

Both generations in Yemen	63± 7%
Second generation migrated to Palestine at advanced ages	52±10%
Second generation migrated to Palestine at younger ages	19± 6%
First generation migrated to Palestine, second generation born in Palestine	16± 7%

The high percentage of cases of heredity of occupation may be held as characteristic of a static society. Moreover these data confirm the reports of travelers about the occupation distribution of Jews in Yemen. Also the father and grandfather of a family of the sample were mostly craftsmen, a few peddlers and very few in the religious profession (rabbi, teacher, scribe).

* * *

There is also a rather convincing amount of evidence that most of the immigrants reached Palestine in the same economic conditions.

In fact:

(a) As already seen, the greatest part of Jews of Yemen are very poor[2].

(b) The first settlers belonged to the poorer section of the community. Even in these times immigration into Palestine was an adventure full of dangers and it is quite understandable that the poorest ones were the most eager to move in search of a better lot, as they had nothing to lose.

(c) Later, when even well-to-do Jews began to look to Palestine, the Iman ordered the possessions of Jews leaving the country to be impounded.

(d) These who succeed in reaching the port of embarcation, Aden, with some money, spend it while waiting there for an immigration certificate.

(e) Only a few merchants who had business connections with foreign countries succeeded in bringing to Palestine considerable sums and they were excluded from the sample, as will be seen later.

As these various sources point in the same direction, it may be concluded that the hypothesis is reasonably proved and that Yemenite Jews

[1]An attempt to collect more complete data on father and grandfather did not give satisfactory results.

[2]Ishayahu (Ref. 15, p. 43) says "Whoever possesses 100 pounds is called rich."

reached Palestine in the same social and economic conditions, no matter what the time of immigration.

Yemenite Jews in Palestine number approximately 29,000. Jews still in Yemen are estimated to be about 45,000-50,000: 9,800 Yemenite Jews immigrated into Palestine, i.e., about 24% of the Jewish population of Yemen. It would be interesting to know whether these settlers are a selected group of the Jewish population of Yemen. No data, however, are available on this point.

In 1939, 3,772 Yemenite Jews lived in Jerusalem, i.e. about 628 families. About 90-95% of them came from Sa'ana, the capital town, the others from other urban centres and a few, about 10-12 families, from villages. The first immigrants settled all in Jerusalem, while in successive "waves" of immigration only part of the settlers chose Jerusalem as their residence, many going also to Tel Aviv and the colonies.

The fact that almost all Jerusalem's Yemenite Jews came from the same town, Sa'ana, augments the homogeneity of the sample.

II. Preparation of Material

4. *Selection of Sample.*

A list of the male Yemenite Jews above the age of 21 years, living in Jerusalem in 1946, was drawn up chiefly from the files of the Yemenite Jewish Community Council. It included 750 names. Since, according to 1939 Census there are in Jerusalem about 628 families and since Yemenites marry early, it may be claimed that the list included all—or almost all—the heads of family.

Then further restrictions were introduced in order to eliminate certain factors that may be presumed to influence the culture traits to be measured. So the following were struck from the list:

(a) Bachelors, widowers and divorced.

(b) Heads of family below age of 30 or above 45.[3]

(c) Invalids and chronically ill.

(d) Heads of family who (themselves or their fathers) did not come to Palestine directly from Yemen (i.e. that were in other countries too).

(e) Heads of family that after their immigration into Palestine lived longer than one year outside Jerusalem.

After a first selection according to these criteria about 300 families remained. All of them were interviewed in order to make sure that they

[3]Many of the early settlers were above this limit—so their sons were studied instead.

respond to the specifications set up above. This reduced further the sample to 139 families. This study, however, is based only on 117 of them, because the proclamation of martial law in Jerusalem made the continuation of field work impossible.

The frequency distribution of the families according to year of immigration is shown in Table I.

TABLE I

DISTRIBUTION OF SAMPLE FAMILIES ACCORDING TO LENGTH OF RESIDENCE IN PALESTINE

Length of residence in years	Frequency
75 (i.e. from 78 to 73)	2
70	8
65	4
60	12
55	3
50	9
45	3
40	8
35	7
30	4
25	12
20	15
15	17
10	5
5	8
	117

5. *Selection of Culture Traits.*

The problem of choosing the culture traits to be measured was studied at some length. There are, however, no satisfactory criteria for the choice of culture traits as a suitable, non-overlapping classification is still lacking (cf. Ref. 1, ch. III).

At last the following traits were selected.

(a) Demographic[4] traits:
  (1) Fertility;
  (2) Age of husband at marriage;
  (3) Age of wife at marriage;

(b) "Social"[4] traits:
  (4) Socio-economic status;
  (5) Friendship towards Jews belonging to other communities;
  (6) Attitude towards Sabbath observance;
  (7) Hygienic status.

[4]No special meaning is attached to the words "demographic" and "social" used here. They are intended simply to designate the two groups of traits.

The choice of these traits justify why, in selecting the sample, an attempt was made to exclude the influence of such factors as age, ability to work. mobility, etc. There is in fact some evidence from previous investigations that such factors influence Socio-Economic Status and perhaps other traits too.

6. *Measuring Scales.*

The next problem was to measure quantitatively each one of the traits.

Age is usually expressed quantitatively and no problem at all arose here.

For the measurement of fertility, the chief aim was to construct an index that allows for the comparison of the number of children of women of different ages. The following procedure—suggested by Professor R. Bachi—was adopted:

(a) The mean number of children born to the women of our sample up to the age of 15, 16, 17, . . . , 45 was calculated.

(b) The index of fertility of a certain woman is the ratio between the number of her children and the mean number of children of women of the same age, as this woman, in the whole sample. Living children only were taken into account, as it was found impossible to trace the year of birth of children who had died. The series obtained by (a) was smoothed by free hand method in order to correct fluctuations due to smallness of sample.

Socio-economic status was measured by a standardized scale constructed for this purpose (Ref. 16).

For the measurement of attitudes towards Sabbath observance an equal-i scale was constructed and tested (Ref. 16 and 17).

For the measurement of friendship towards Jews belonging to other communities (i.e. non-Yemenite) the following simple test was prepared:

(a) Name your three best friends.

(b) Are they Yemenite, Oriental, Sephardic or Ashkenazic Jews?

If the respondent had a non-Yemenite among the first three best friends, he was given a score of 25, 20, or 15 points according as the non-Yemenite was his first, second, third best friend. If the respondent had more than one non-Yemenite friend, among the first three, the points were summed up to provide a total friendship score.

The scores therefore have the following meaning:

60 points: first three best friends non-Yemenite.
45 points: First and second best friend non-Yemenite.
40 points: first and third best friend non-Yemenite.
35 points: second and third best friend non-Yemenite.

25 points: first best friend non-Yemenite (second and third Yemenite)
20 points: second best non-Yemenite.
15 points: third best non-Yemenite.
0 points: first three best friends Yemenite.
—10 points: to the reply "I have no friends at all".

No attempt was made to determine whether the non-Yemenite friends belonged to the Ashkenazic, Sephardic or Oriental groups. There are however some indications that in the first period of settlement Yemenites make friends chiefly with Oriental and Sephardic Jews; later they turn to Ashkenazic. This may explain the drop in friendship scores observed between 40 and 60 years of settlement (see Fig. 1) which will be seen below.

It may be mentioned that, as in 1939 there were in Jerusalem 80,850 Jews, of them 3,772 Yemenite, the chance to have a Yemenite friend in a pure random choice was about 5%, to have two 0.25%, and to have three 0.0125%.

The hygienic status was measured by Dodd's brief scale (Ref. 7). This brief scale comprises 20 scored questions with a maximum possible score of 500 points. It was derived from the standard scale of 55 scored questions earning a possible 1,000 points, constructed by Dodd for the measurement of hygienic status in Syrian villages.

In order to adapt the brief scale to conditions in Jerusalem, questions on malaria, smallpox and mosquito control had to be dropped as not suitable. This left 100 points free that were used in the following manner:

(a) Rooms-Persons Ratio in dwelling: $\frac{\text{40 times N° of rooms}}{\text{N° of persons}} = \text{Score.}$

When there is one room or more for each person in the dwelling this question obtains the maximum score of 40 points.

(b) Family has a separate lavatory? If yes: 30 points.

(c) How many persons use the same lavatory? $\frac{30}{\text{N° of users}} = \text{Score.}$

If there is one lavatory for each person this question obtains the maximum score of 30 points.

These three questions together obtain a maximum score of 100 points. The last two questions seem to be of particular importance in view of the high rate of infective intestinal diseases found among Jerusalem Jews.

Of the four scales prepared for the measurement of social traits two (Socio-Economic Status and Sabbath) were standardized and tested. Because of budget limitations it was not possible to test the sociometric and hygienic scales.

Some steps were, however, taken in order to reduce both variable and constant error of reliability (cf. Ref. 7). They may be summed up as follows:

(a) Socio-Economic Scale: Reliability, by split halves method: $r_{raw} = .75$; $r_{corr.} = .86$.[5]

(c) Certain types of error were eliminated by interviewing in one season only, with one schedule only, by one interviewer only (the writer).

(d) Informant error: No effort was spared to win the informant's confidence (see paragraph on field work). Both husband and wife were interviewed in each case, certain questions being constantly asked to the husband and certain others to the wife. Wherever possible (as for instance in questions on age and age at marriage) replies of husband and wife were confronted and checked.

(e) Socio-economic and Sabbath scales were tested for the single factor hypothesis. Both measure a single factor.

Although the age range of the sample is rather narrow it was, however, possible that age—even within these limits—could influence the socio-economic status or the attitude towards Sabbath observance. It was also possible that socio-economic status might be influenced by the number of children. These three hypotheses were tested by comparing: (a) the mean value of the socio-economic status scores for husbands above 37 years of age with that for husbands below 37 years; (b) the mean value of the socio-economic status scores for families with five or more children with that for families with four children or less; and (c) the mean Sabbath score for husbands over 37 years of age with that for husbands below 37 years.

In one case there was no difference at all between means; in the others the differences were about of the same size as their respective standard errors and are therefore not significant.

7. *Field Work Technique.*

The field work was carried out between October 1946 and February 1947, with many interruptions due to imposition of curfew. The disturbed political situation made the work more difficult. Nevertheless the confidence of the families to be interviewed was gained and in the whole survey there were only four refusals to furnish information.

A more detailed account of field work technique will be found in the microfilm edition.

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[5]Factor analysis shows, however, that this value is too low.

III. Analysis of Data

8. *Analytical Representation of Change.*

By introducing restrictive conditions in the selection of sample some factors were fixed.

Which other factors influence the situation and were left uncontrolled? It is difficult to give a satisfactory reply to such a question. But surely at least two factors could not be controlled:

(a) Period of residence of wife in Palestine. In most cases there was no great difference between the time of immigration of husband and wife. Some cases were, however, found of comparatively new settlers who married girls born in Palestine, or who came here in early childhood. In these cases the influence of the wife in raising the standard of the family was rather evident. Nevertheless these cases were not excluded from the sample in order not to reduce it further.

(b) The most important factor not measured were individual abilities. It would have been extremely interesting and useful to measure the ability of adjustment of each head of family and of his wife and to see how much it influenced the time trend.

Unfortunately it was not possible to do it, chiefly because of budget limitations. So the settlers were classified according to the year of immigration in groups of five-year intervals and for each group the mean value in standard deviation units was accepted (Tables II and III). The seven series so obtained were smoothed by moving weighted averages of three groups, each average being weighted by the number of cases in its group. The smoothed series were fitted, by method of least squares to logarithmic curves of the type: $y + 1.3 = \log_e (ax + b)$, where y is the standard score in 1946 of a group who came to Palestine x years ago. a and b are the two constants characterizing each curve. The constant 1.3 was added in order to eliminate negative values of y.

The following are the functions of each trait (variables *1*—fertility—and *6*—Sabbath observance—were reversed in sign, so the upward trend indicates a diminution both of fertility and Sabbath observance):

1. Non-fertility: $y + 1 = \log. (.039x + 2.09)$
2. Age of husband at marriage: $y + 1.3 = \log. (.024x + 2.62)$
3. Age of wife at marriage: $y + 1.3 = \log. (.019x + 2.75)$
4. Socio-Economic Status: $y + 1.3 = \log. (.112x + .44)$
5. Friendship towards other Jews: $y + 1.3 = \log. (.048x + 2.28)$
6. Non-Sabbath observance: $y + 1.3 = \log. (.057x + 1.99)$
7. Hygienic Status: $y + 1.3 = \log. (.062x + 1.84)$.

TABLE II

MEAN SCORES AND STANDARD DEVIATIONS OF TRAITS STUDIED

Trait	Mean	Standard Deviation	
1. Fertility Index	1.01*	0.51	
2. Age, in years, of husband at marriage	21.92	4.14	Mean for Palestine Jews (Average 1938-39) 25.75 years.
3. Age, in years, of wife at marriage	16.62	4.58	Mean for Palestine Jews (Average (1938-39) 21.94 years.
4. Socio-Economic Status Score	84.85	13.05	Maximum Score 125 points.
5. Score of Friendship towards Jews of other communities	13.72	21.80	Maximum Score 60 points.
6. Score of attitude towards Sabbath Observance	7.86	1.89	Maximum Score 10.48 points.
7. Hygienic Status Score	295.02	37.78	Maximum Score 500 points.

TABLE III.

DISTRIBUTION OF MEAN STANDARD SCORES BY YEAR OF IMMIGRATION

Years in Palestine	Culture Traits 1	2	3	4	5	6	7
5—	+.82	—.46	—.57	—1.29	—1.04	—.37	—.59
10—	—.21	—.46	—.35	—1.37	— .81	—.41	—.80
15—	—.25	—.22	—.13	— .76	— .45	—.72	—.46
20—	—.45	+.02	—.13	— .15	+ .19	—.04	—.01
25—	—.14	—.46	—.13	+ .01	— .04	—.08	+.05
30—	+.31	+.26	+.08	— .22	+ .74	+.52	—.75
35—	—.21	+.26	—.13	+ .31	+ .28	—.04	+.68
40—	—.17	+.02	+.30	+ .62	+ .19	+.14	+.55
45—	+.84	+.26	+.74	+ .54	— .08	+.65	+.52
50—	—.08	+.02	—.35	+ .31	+ .28	+.41	—.43
55—	+.43	—.46	—.79	+ .01	+ .51	—.32	+.18
60—	+29	+.02	+.30	+ .62	+ .38	+.37	+.29
65—	—.29	+.02	—.13	+ .93	+ .28	+.34	+.39
70—	+.29	+.26	+.08	+ .93	+ .19	+.56	+.81

*The fertility Index measures the probable final number of children of mother at the end of the fertility period. It may vary from *0*, when the final number of children is 0, and reach the value of 2.17 when the final number of children is 12. Being a measure of internal variance of the group, its mean is obviously around 1 and has no special significance otherwise.

The fitting was tested by the usual χ^2 method comparing fitted and smoothed values. The values of χ^2 and P obtained are reported in Table IV. Smoothed raw points and mathematically fitted curves are reproduced in Fig. 1. While some of the traits show an excellent fit, in others the fit is not so good. It is possible that deviation from the curves are mainly due to uncontrolled factors.

As a further check on fitting the t-test of significance of the differences between mean scores of the first and last ten-year groups was also calculated. Results are reported in Table V.

TABLES IV-V

χ^2 AND P VALUES FOR TEST OF GOODNESS OF FIT, AND P VALUES FOR "t" TEST OF SIGNIFICANCE, OF DIFFERENCE BETWEEN MEANS OF FIRST AND LAST TEN YEARS, OF GRAPHS OF FIGURE 1

	Trait	Degrees of freedom	χ^2	P (approximate) of χ^2 test	of t test	
1	Fertility	9	0.2023	.99	.50	not significant
2	Husband's marriage age	11	2.7460	.99	.20	
3	Wife's marriage age	11	7.6791	.70	.30	
4	S.E. status	11	.4760	.99	.01	significant
5	Friendship	11	6.7911	.80	.01	
6	Non-Sabbath	11	.7049	.99	.03	
7	Hygiene	11	4.0649	.98	.01	

NOTES:

(a) Degrees of freedom = Number of raw points — 3 (N.° of points, Mean S.D.).

(b) In trait 1 there are two raw points less, as it was impossible to obtain reliable data on fertility of settlers who came in the latest years.

While the differences of the social traits are significant, those of demographic traits are not. It may be argued that demographic traits are static and differences are due to accidental fluctuations. But it seems rather that their process of change is so slow that for the range of observation of the present study it is observed by accidental fluctuations. It can be said in favor of the second hypothesis that it is difficult to conceive that demographic traits remain static while social traits undergo such a rapid change. It may be that demographic traits follow the process of the social ones with a lag. This hypothesis will be explained later.

Now a further step should be made. The curves which were obtained (see Fig. 1) show the status in 1946 of groups of settlers who came to Palestine 5, 10, 15, . . . 65, 70 years before that date. They do not describe how the status of the first group (which settled 70 years ago) changed in this period of time. Obviously the change undergone during the years

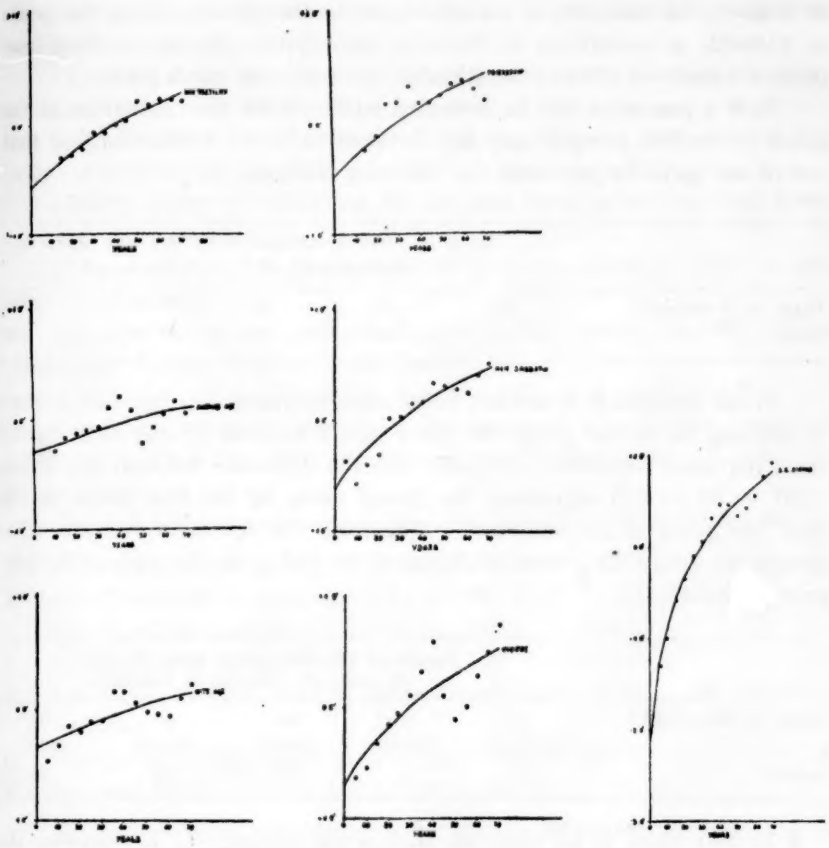

FIGURE 1

Smoothed points and logarithmic curves mathematically fitted. The graphs show the difference in status today, according to the seven variables measured, of the respective groups of Yemenite Jews who settled in Jerusalem 0, 10, 20, . . . , 70 years ago.

The notation 0σ in the graphs indicates the mean of all groups. The goodness of fit is reported in Tables IV-V.

"Non-fertility" means index of fertility of mother reversed in sign. So the upward trend indicates a diminution of fertility.

"Husband and Wife age" means age at marriage.

"Friendship" means score of friendship towards non-Yemenite Jews.

"Non-Sabbath" means attitude towards observance of Sabbath reversed in sign.

"Hygiene" means hygienic status score.

"S.E. Status" means Socio-economic status score.

of 1940-45, for instance, is not equivalent to the change during the years of 1880-85, as conditions in Palestine were quite different in these two periods, namely in 1940-45 the stimulus to change was much greater.

Now a procedure will be presented which allows the calculation of the status of the first group at any date between 1876 and 1946. Suppose that one of our variables presented the following changes:

	Scores in 1946 of groups of settlers who came to Palestine 50, 55, . . . 70 years ago				
Years in Palestine:	50	55	60	65	70
Score:	20	50	75	90	100

If the first group of settlers (who came 70 years ago) has now a score of 100 and the second group (65 years ago) a score of 90 and both started from the same conditions, it means that the difference between the scores ($100 - 90 = 10$) represents the change made by the first group in the first five years of its settlement. Repeating the operation for the other groups, we obtain the amount of change of the first group for each of the five-year periods:

	Scores of the first group after 50, 55 . . . 70 years of residence in Palestine				
Years in Palestine:	0	5	10	15	70
	100-10(x)	100-90	100-75	100-50	100-0
Score:	0	1	25	50	80

In fact there is no need for such a calculation. If we observe the curves of Fig. 1 upside down we will see the curve of change of the first group. This curve is a reversed logarithmic showing at the beginning a very gentle slope which becomes markedly steeper in more recent years. To observe the curve upside down is equivalent to translate and rotate the co-ordinate axes until the zero point passes to the upper right end corner of Figure 1.

In order that the values obtained by the functions expressed in the new coördinates shall be standard values the new zero point should be chosen adequately. Its coördinate on the x-axis (years) will surely be *70* as the first settlers came 70 years ago and this is their starting point.

[1]Supposing the starting point to be *zero* score.

The coördinate of the new zero on the y-axis (score) should be such as to satisfy the following conditions:

(a) Score at the starting point should be the score of settlers who came to Palestine in 1946, i.e. log. b.

(b) Score at the final point should be the score—in 1946—of the first group of settlers, i.e. log. (70a + b).

Calling q the y coördinate of the new zero point we shall have: $q = \log. (70a + b) + \log. b - 1.3$.

(The constant 1.3 is now subtracted as it was added in order to simplify calculations.)

By substituting the new coördinates in the general function of the curves the following function is obtained:

$$w = \log. (70a + b) + \log. b - \log. (70a + b - at) - 1.3$$

where w is the standard score of the first group of settlers after t years of residence in Palestine. This function satisfies the conditions (a) and (b) set up above.

The functions of each one of the traits measured, are as follows:

1. Non-fertility: 1.00 — log. (4.82 — .039t)
2. Age of husband at marriage: 1.11 — log. (4.30 — .024t)
3. Age of wife at marriage: 1.11 — log. (4.08 — .019t)
4. Socio-economic Status: —.01 — log. (8.28 — .112t)
5. Friendship towards Jews of other communities: 1.24 — log. (5.64 — .048t)
6. Non-Sabbath observance: 1.16 — log. (5.98 — .057t)
7. Hygienic Status: 1.12 — log. (6.18 — .062t).

By differentiation the functions of velocity (v) and celeration (c) at time t are both obtained:

$$v = \frac{dw}{dt} = \frac{a}{70a + b - at}$$

$$c = \frac{dv}{dt} \frac{a^2}{(70a + b - at)^2}$$

9. *Meaning of Analytical Functions as Compared With Non-Quantitative Experience.*

Each function is characterized by two parameters a and b. Log. b is the standard score when $t = 0$. a is a parameter of the rate of change. The higher the a value the more rapid the change. Demographic traits have a slower rate of change than social traits.

Now in order to compare critically the functions found with the experience gained by non-quantitative methods two questions should be asked:

(a) Is the time trend described by the functions confirmed by the history of Yemenite settlement in Palestine generally and in Jerusalem in particular?

(b) Are these functions useful in forecasting future developments?

(a) The functions show that change was very slow up to about 20-25 years ago, then it gained rapidly in velocity (observe curves of Fig. 1 upside down). This is particularly true of the socio-economic status. Taken as a whole, the process of change indicates that Yemenite Jews show an increasing tendency towards adopting the ways of living of Jewish settlers from Europe: lower fertility, later marriage, higher socio-economic and hygienic status, less strict observance of traditional religious precepts, tendency to change their we-group from their own community to the whole Jewish community in Palestine. The agency of this process is—to indicate it with a global name—Zionist settlement in Palestine, with its consequences of introduction of western ideas and methods, opportunities for better employment, higher wages, social services, better educational facilities etc. Now it is perhaps no mere coincidence that economic indexes for Palestine show a rapid upward trend beginning at about 1923 (Ref. 2, p. 50-52). Moreover, history of Yemenite settlement in Palestine points out that first settlers had to overcome many difficulties in order to adjust themselves to the country. They lacked the western ability for organization and coöperation, lacked proper vocational training, moreover their problems were different from those of western Jews and settlement agencies had to become acquainted with them. So quite a lot of time passed before Yemenite Jews learned to organize themselves and organize the reception and training of their fellows who continue to stream to Palestine.[8] It is significant that as late as 1928 Hurwitz published a booklet urging Western Jews to help Yemenites to settle in Palestine.

While carrying out the field work the writer had the opportunity of hearing tens of personal stories of settlers. These stories are full of details of the difficulties of the first years of settlement.

The reasons behind the rapid improvement of socio-economic status of Yemenite Jews after 1920 are well explained by A. Tabib. Yemenite Jews are sober, hard working people; they were used to eat little and had no need for the amenities of western living. So they were able to keep

[8]Cf. Bibliography.

their expenditure low while enoying the good wages paid in Palestine to manual labor, wages which are in keeping with the western standard of living. Of course, this picture has changed now as the process of westernization has advanced and generally speaking the standard of living is much higher than before. This is shown also by the high correlation between socio-economic status and expenditure (Ref. 16).

(b) Now to the second question: Forecasting of future developments.

It is unlikely that the present accelerated upward trend can continue for long, as it would bring obviously absurd results eventually.

It has been already observed that the process undergone by these Yemenite families may be called a process of westernization, a process of imitation of the ways of living of European Jews. When the status of Yemenite will approach the status of European Jews the velocity of change is likely to drop progressively and almost to stop when the process of fusion shall be completed.[9] If this hypothesis is true, the curve of the whole process will be of the type of a logistic curve.

The fitting of socio-economic status time series to a logistic curve will be presented here. As upper limit the value of + 2.00 S.D. (equivalent to 110 points in the S.E. scale) was taken. This is the status of a rather well-off family of the middle class. It seems unlikely, unless economic conditions change revolutionarily for the better, that the mean score of the Yemenite may exceed this limit. The logistic was fitted by the procedure suggested by Pearl. As the exponential values observed were neither exactly nor even nearly on a straight line, they were fitted (by the method of least squares) to a parabola of third degree.

The function of the logistic curve is the following:

$$w = \frac{4.12}{1 + 10^{2.0251152 - .0733747 4t + .001540508t^2 - .0000140668t^3}} - 2.12$$

where, as usual, w is the socio-economic status, in standard units, at time t; -2.12 is the lower limit, i.e. the status when $t = 0$, $+4.12$ is the difference between the lower and the higher limit: $+ 2.00 - (-2.12) = + 4.12$. Obviously this logistic is asymmetric. The bases of decimal logarithms have been used, but the function may be easily changed to the bases of natural logarithms.

[9]The degree of social acceptance of the Yemenite among other Jews is of course an important factor in the process of assimilation. For some data on this point see Ref. 14.

In Fig. 2 are reproduced smoothed raw points and reversed logarithmic and logistic curves, both mathematically fitted. There is no appreciable difference in the fitting of the two curves to the smoothed raw points. The logistic suggests that it will take about 30 years for Yemenite Jews

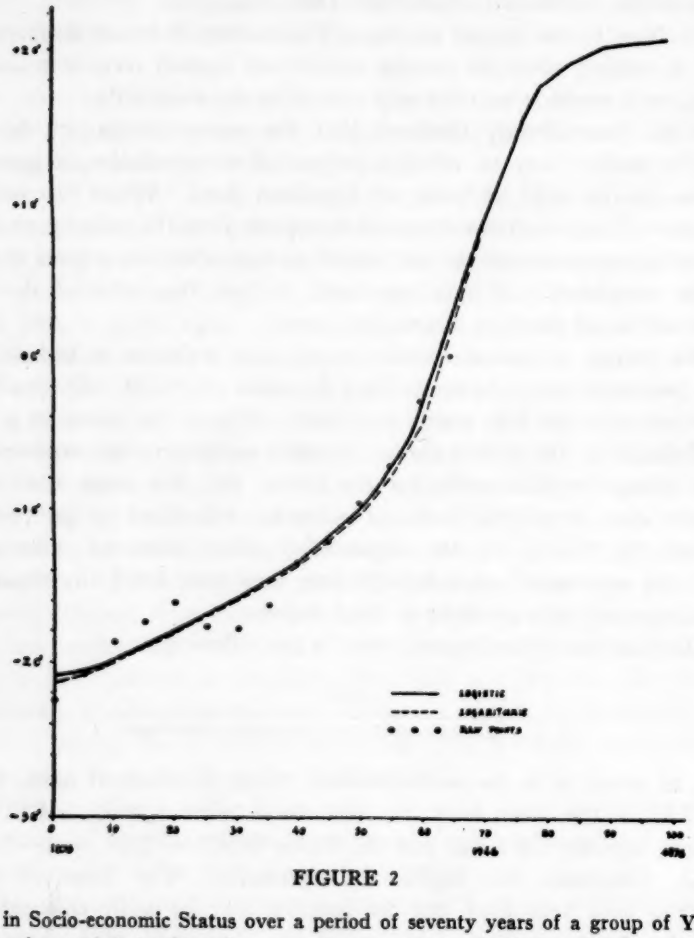

FIGURE 2

Change in Socio-economic Status over a period of seventy years of a group of Yemenite families who settled in Jerusalem seventy years ago. Both logarithmic and logistic curves are mathematically fitted to smoothed data. There is no practical difference in the fitting of the two curves, hence the goodness of fit for the logarithmic reported in Tables IV-V is essentially valid for the logistic too. This latter curve tries to describe the future trend of change.

to reach the assumed maximum socio-economic status, provided of course that external conditions do not change.

By the same procedure a logistic could be fitted to the other variables. The logistic forecasts a cycle at change which approaches a limit and hence seems more reasonable for forecasting than the log curve that forever accelerates. But for lack of time and resources in the present disturbed state of Palestine the author would have forecast all seven variables in logistic surges.

10. *Intercorrelations Among Culture Traits.*

The product-moment correlation between each possible pair of raw scores of the seven traits was calculated. The correlation matrix is shown in Table VI. The limit of significance for 117 cases is .18. When—as done

TABLE VI
CORRELATION MATRIX OF CULTURE TRAITS

		1	2	3	4	5	6	7
1	Fertility	——	.2447	.3904	.1489	—.0462	.2558	—.2136
2	Husband's marriage age	.2447	——	.6124	.2321	.1457	.3265	.2202
3	Wife's marriage age	.3904	.6124	——	.2641	.1086	.4311	.1744
4	Socio-economic status	.1489	.2321	.2641	——	.7963	.9259	.5526
5	Friendship	.0462	.1457	.1086	.7963	——	.2945	.2290
6	Non-Sabbath	.2558	.3265	.4311	.9259	.2945	——	.2830
7	Hygiene	.2136	.2202	.1744	.5526	.2290	.2830	——

Nota: Variables *1* and *6* are reversed in sign.

in time series—traits *1* and *6* are reversed in sign, almost all the correlations become positive.

As could be expected, fertility is rather highly negatively correlated with age of wife at marriage. It is also positively correlated with attitude towards Sabbath, confirming the well known fact that religious mothers are more prolific; and negatively correlated with husband's age at marriage and positively with hygienic status. This last correlation is probably due to the following accidental cause: The scale or hygienic status includes questions on the care of children. All the families interviewed, even if at low hygienic status, follow the instructions of the child welfare stations for the care of babies and therefore families with infants get a better score than infantless families, in which score on child welfare was interpolated.

Naturally, age of husband and wife at marriage are rather highly correlated between themselves. They are also correlated with socio-economic status (higher status means later marriage) and negatively correlated with Sabbath observance.

Socio-economic status is very highly negatively correlated with Sabbath observance. This shows that well-to-do people have a tendency to relinquish traditional ways of living. It is also highly—but positively—correlated with friendship towards Jews of other communities and with hygienic status.

Friendship is negatively correlated with Sabbath observance and positively correlated with hygienic status.

There is also a negative correlation between Sabbath observance and hygienic status.

The meaning of these findings will be better understood after factor analysis of the correlation matrix.

11. *Factor Analysis of Culture Traits.*

The centroid method (Ref. 13) was used for the factorization of the correlation matrix. After the extraction of the third factor all residuals (except of residuals of trait 5, Friendship) dropped below the error limit. After extraction of the fourth factor also the remaining residuals (Trait 5) approached zero.

However, as the fourth factor was rather small and its introduction would have considerably complicated the calculations and the interpretation of results, it was dropped in subsequent elaboration.

After correction for uniqueness, the trait vectors were graphed on the surface of a ball (Ref. 13, p. 164) and the new reference vectors were thus found graphically. The matrix of the trait vectors described by the new coördinates is given in Table VII. The projection of the portion of ball surface including the trait vectors and the new reference vectors is reproduced in Fig. 3.

TABLE VII
DIRECTION COSINES AFTER ROTATION

	A	B	C
1	—.24	.99	.30
2	.73	.40	—.03
3	.54	.61	.12
4	.57	—.08	.70
5	.08	.17	.96
6	.83	—.08	.39
7	—.17	.35	.99

Table VII giving the centroid coördinates and direction cosines may be consulted in the fuller version in Bibliofilm cited above.

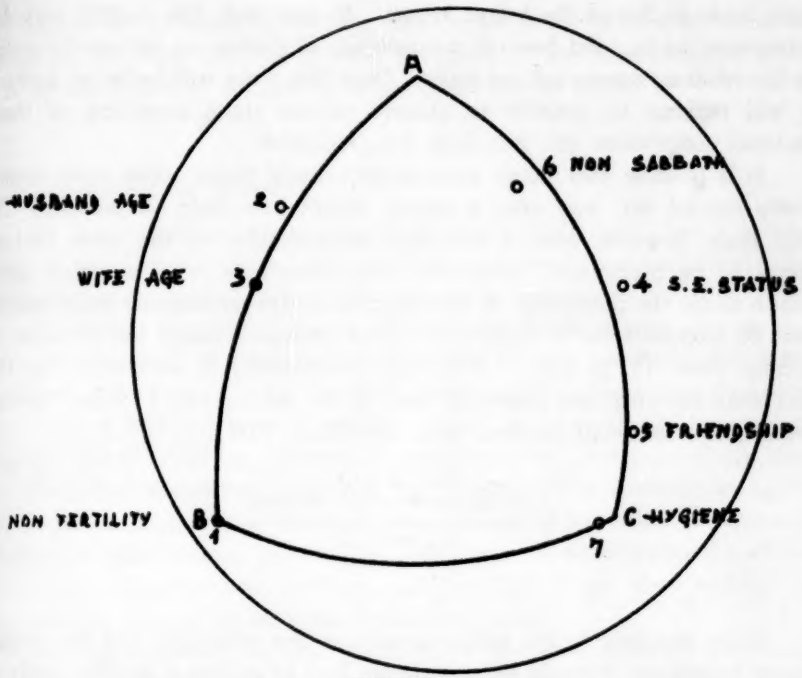

FIGURE 3

PROJECTION OF THE FACTOR STRUCTURE OF THE SEVEN CULTURE TRAITS

The diagram represents the surface of a sphere. A plane passed through the center of the sphere and the points A and B contains approximately three variables (1, 2, 3). The other four variables (4. 5, 6, 7) lie near or on a plane passed through the center and points A and C. The points 1, 2, 3, 4, 5, 6, and 7 indicate the intersection of the vector of each trait (the origin of each vector being the center of the sphere) with the surface of the sphere. The smaller the distance between the points, the higher the correlation between the points, the higher the correlation between the corresponding variables. The seven cultural variables are here seen to be reducible to three factors.

From the factorial analysis it is learned:

(a) That the seven traits lie in a three-dimensional space, i.e. they may be described by three factors (for trait 5 see above).

(b) That the demographic traits lie in a plane (AB in Fig. 3) and the social traits in another plane (AC in Fig. 3). This is what Thurstone calls a simple structure. However, as no traits lie in the plane BC, different structures are possible, i.e. this structure is not unique.

There is no agreement among writers (Ref. 12 and 13) about the scientific significance of such a finding, at least as far as psychology is concerned. In the sociological field no researches of such a kind have yet

been made as far as the writer knows. In any case, this finding may be interpreted as to point towards a possibility of finding an underlying order in the relations among culture traits. Once this order will be better known, it will perhaps be possible to classify culture traits according to their factorial composition (cf. Ref. 1, p. 146, 162, 328).

It is possible that factor analysis of cultural traits, when more extensively carried out, may offer a deeper insight into their relationship. At this stage, however, even a tentative interpretation of the three factors seems to be premature. Moreover, even Thurstone, who is rather optimistic about the possibility of finding primary (psychological) traits warns that no interpretation of factors should be attempted unless the structure is unique (Ref. 13, p. 155). A further complication is introduced by the fact that the structure presented here is not orthogonal, i.e. that factors are slightly correlated between them (see Table VIII).

TABLE VIII
CORRELATION BETWEEN FACTORS

r_{AB}	$= -.24$
r_{AC}	$= -.17$
r_{BC}	$= +.25$

Since two only of the scales were tested for reliability and the single-factor hypothesis, it would be of little use here to go into a detailed analysis of common factors, specific factors and error factors of each trait. Values of h^2 (common factor) are, however, reported in Table VIII. It is of a certain interest to note that socio-economics status has no specific factor. Also in the Sabbath trait the specific factor is almost absent (Cf. Ref. 39 and 40). Cultural variables without specific factors are rare. When they exist, as here, there is much better possibility of prediction from multiple correlations approaching unity within the system of variables studied.

In any way the foremost problem remains what is the degree of constancy of this structure, i.e. may it be found in other populations? Perhaps the degree of constancy of factor structure is the test of its usefulness in the formulation of a more exact theory of Sociology.

12. *The Construction of a System of Forces.*

Now for each trait it is known:

(a) The angles between the trait vector and the reference vectors, as well as any other trait vector (cf. Fig. 3).

(b) The length of each vector, i.e. the Force of each trait (Force = Population $\times$ Celeration).

Then all the elements for the construction of a system of forces as suggested by Dodd (Ref. 1, ch. XI) are known. We hope that this point will be the object of a paper to be prepared in the future.

IV. Conclusions

13. *Methodological Remarks.*

(i) The procedural pattern presented in this study shows how it is possible, in peculiar situations, to trace down and describe quantitatively the social change undergone by a certain population over a long period of years.

(ii) When the social behavior of relatively simple groups—as the one studied here—shall be better known, it will be perhaps possible to introduce more and more factors in the study of the situation, as for instance a larger age range, a higher degree of mobility, as well as to study the behavior of migrant groups when the situation is changing in the country of origin also.

(iii) The measurement of all relevant factors remains, however, an objective to be attained. As in this study, the influence of individual abilities and perhaps of other factors, too, was not measured. A considerable simplification of the situation was, however, attained and it was thus possible to describe the change by algebraic functions.

Another deficiency of this study is the fact that some of the scales were not tested. It will be noted that tested scales give more regular results.

(iv) The basic postulates of Dodd's dimensional s-system were very useful in the formulation and study of the problem.

(v) The factor analysis of the intercorrelation between the traits studied shows that, at least in this case, the relationship among culture traits follows a certain order. It will perhaps be possible—in future—to classify traits according to their factorial composition. Such a possibility would be of revolutionary importance in social research. The reduction of seven traits to three factors and the absence of specifics in two of the traits seem clean-cut findings on which further computations and deductions may be made.

14. *Factual Remarks.*

Yemenite Jews settled in Jerusalem tend to relinquish their traditional ways of living and to acquire the habits of Western Jews who constitute the larger and dominant part of the Jewish community of Palestine.

In the first period since beginning of their settlement in Palestine, i.e.

from 1876 to about 1920, the process has been slow. But from 1920 onwards it has shown a tendency to a progressive acceleration. At this stage at last, social traits tend to change more rapidly than demographic traits.

It may be supposed that, as the status of Yemenite Jews approaches the status of Western Jews, the velocity of change will reduce progressively. In this case the whole process will be represented by a probably asymmetric logistic curve. It should then be expected that in the next 20-30 years the velocity of social traits will decrease, while the velocity of demographic traits will increase, i.e. fertility will become lower and age of marriage higher both for husband and wife.

This hypothesis of a "lag" between social and demographic traits may also explain why, in the factor analysis, they group separately. The seven traits are describable by three factors, one highly common to all seven, one common to the four "social" traits and the third common to the three demographic traits.

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A DIMENSIONAL THEORY OF GROUPS

VLADIMIR CERVINKA

*Reported by Stuart C. Dodd**

This paper proposes a theory of human groups which analyzes the structure of any group whatever into two types of measurable elements and the relations among them.

The dimensions, or measured parts, of any group are analyzed as:

(a) *Persons* (i.e., "situation selves" or the part of an individual's total personality which responds to the reference points of, or which is involved in, the group situation).

(b) *Reference points* (i.e., any *group-generating stimuli,* or mediants of interrelation among the group's members. These group generating stimuli may be other persons, material things, events, patterns of them, symbols, or anything that acts as a natural or conditioned stimulus to bind people into a group or entity as defined by the tests described below). Non-personal group-generating stimuli will be called "reference points," while if persons are included, they will be called "reference entities."

(c) *Relations among them* (especially *attitudes* of persons to other persons and to the reference points).

Let the persons and reference points form a *matrix* by listing each person and each reference point as head of a column and each person and reference point again as head of a row in a rectangular tabulation. A relation is the cell entry relating each cell's column and its row in this second degree matrix. With any number, n, of kinds of relations, there will be n such matrices, but only one kind is studied in this paper, namely, the relation of *attachment-aversion* which is summarized into an index of group *solidarity.*

To get this index of solidarity one starts by getting the ratings by each person of his degree of attachment to each other person and to each reference point, by means of an attitude scale which Cervinka has devised. (See below.) A weighted sum of these attachments between persons, which are

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*Mr. Cervinka's paper was solicited by the guest editor for this issue of SOCIOMETRY. It proved too long and too mathematical for SOCIOMETRY readers. Consequently the editor has abstracted it, with the permission of his former student.

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entered in the cells of the matrix, yields an index of group "*cohesion*"; a weighted sum of the attachments between persons and the reference points yields an index of group "*stability*"; the weighted combination of this measured cohesion and stability is called the group's "*solidarity*". A major hypothesis is that these indices of cohesion, stability and solidarity of a group will correlate with (and so predict) such phenomena as the group's longevity, its unitary or effective functioning in measured respects, and its resistance to disorganizing shock or decay.

The group's "cohesion," being computed from direct interperson attachments, is a current type of sociometric index dealing with primary, or face-to-face, groups. The group's "stability" being computed from indirect, or mediated, attachments of persons to reference points, extends current sociometry to deal with secondary groups whether ranging from small voluntary associations to nations. These secondary groups are becoming increasingly numerous and important in modern society, and any theory of groups must deal with them as adequately as with primary groups.

Cervinka's formulation enables (a) more explicit cataloguing of the myriad kinds of reference points and relations that may bind a group's members together; (b) more exact measurement of each relation; and (c) more complete synthesis of them by using matrix algebra. The cataloguing is comprehensive since any number, even millions, of different dimensions that may be distinguishable can be simply added to the matrix by adding columns and rows to it. It thus can subsume most current theories or descriptions or classifications of groups by calling their properties "reference points" and proceeding to measure and test the contribution of each reference point to the group's solidarity (or to any other summarizing dimension of the group). Exact measurement is furthered in requiring cell entries to be quantities, even if only the primitive all-or-none quantity of the presence or absence of the cell relation at issue. Of course, the reliability (i.e., the self agreement on reobservation) of the attachment indices in cells will vary with the reference point and with the persons rating their degree of attachment. A major field of research is to fix upon the most reliable reference points or simuli which actually and observably bind the group's members together. Synthesis is developed in the theory by multiplying matrices and then averaging their cell entries to get properly weighted but single indices, each measuring some operationally-defined and summarizing aspect of the group's structure. Only the solidarity aspect of a group's structure is illustrated in this paper, although the dimensional theory of groups can analyze any aspect of group structure and functioning whatever.

The theory tests groups as well as defining and measuring them. It can test the solidarity of any specified set of persons or the solidarity resulting from any specified set of reference points used as criteria for that group. Thus, it will test whether a given plurel is a group, i.e., it will tell the extent to which any specified set of persons form a group as defined by any specified reference point or points. Is this high school club a more cohesive group than the members of Church A? Is our nation a more stable group than it was a decade ago? What factors are preconditions of maximal group solidarity? Questions such as these become answerable as fast as the techniques of measurement are applied to the specified populations. Then, conversely, this dimensional theory of groups will further test whether alleged reference points actually do produce a human group, i.e., it will tell the extent to which any specified reference points operating on a plurel yield a cohesive, or stable or solid group. Do enrolled membership, payment of dues, attendance, responses to an opinionaire, etc., specify a group of greater or less cohesion (among a given set of persons at one time) than is specified by another set of reference points? Or another usefully answerable type of question is to identify who is and who is not a group member wherever the membership boundary is not socially visible. Thus, for given reference points and for a given degree of cohesion, the matrices will identify what persons are within the group so defined and what persons in the population studied are outside that group. In short, the matrices can measure any desired dimension for the group as a whole and also measure the contribution in context of each person and of each reference point to it.

This testing of the contribution of each person and of each reference point to the solidarity of the group is done by the two *weightings* referred to above. The persons are weighted for their *cooperativeness-to-competitiveness* and the reference points are weighted for their mutual *compatibility-to-incompatibility*. This means that a matrix of cooperativeness indices and another matrix of compatability indices have to be constructed and multiplied into the matrix of attachment indices in order to weight the latter. Cervinka develops the matrix algebra for pre-multiplying and post-multiplying these matrices together and sketches the geometry of his dimensional theory in diagrams relating the dimensions to each other as lines whose lengths are the attachment indices and whose angles with each other are the cooperativeness and compatibility ratings taken as cosines. To illustrate all these ratings, a scale of attachment, of compatibility and of cooperativeness is appended to this abbreviated paper, though Cervinka stresses that

these scales are only illustrative as yet and need research to calibrate and validate them. They need verbally articulate raters, and this requires training in using the concepts of the theory just as is required for using any other complex scientific instrument. He has applied them to a small sociology class as a test group and computed its solidarity, for example.

In practice the number of ratings will become enormous as the group enlarges or as its complexity yields numerous reference points. Simplifying is then necessary and may be done by grouping the person members and the reference points into a few chief classes. These classes must be reliably ratable ones as tested by the correlation coefficient between repeated ratings. At the limit of simplicity, one reference point only may be used, such as the name of the group. In this case the compatibility matrix is unity and does not influence the computation further; the number of attachment ratings among P persons is $P^{2\,1}$ and the number of cooperativeness ratings is $P^2 - P$; so that the amount of individual rating to be done varies roughly as twice the square of the size of the group. Obviously, for large groups such as a nation, classes of members and classes of reference points and only samples of raters of these from a poll can be handled in practice. This "clustering" or logical summing may be expected to yield "weakened" indices of solidarity.

The cooperativeness rating, as in the appended scale, runs from 0 to ± 1 (so as to yield the cosine of the angle between the two dimensions of the two persons whose cooperating is rated). It expresses each member's judgment, verbally expressed, as to the degree of cooperation-to-competition, of helping vs. hindering, contributed by each other person relative to the rater. Thus in a family group a husband may rate his wife high in cooperation and his mistress, if any, as a competitor or hindrance when the legal family is the reference point. Or in an alleged group of independent "moon worshippers," when they are a plurel who interact in no way with each other, having neither common tradition nor knowledge of each other, the cooperativeness ratings would be zero and so identify this plurel as not being a group. Its cohesion is zero, since weighting the attachment matrix by a zero cooperativeness matrix cancels out the attachments, yielding a cohesion index of zero. These cooperativeness ratings differentiate positive from

[1]Every person rates his attachment to every other person yielding $P(P-1) = P^2 - P$ ratings. Everyone also rates his attachment to every reference point, here only one reference point, which yields $P.^1 = P$ ratings. The total number of ratings here is then $P^2 - P + P = P^2$.

negative interaction of people, associating from dissociating, group "binding" from group "loosening," of course.

The compatability ratings (see appendix here) similarly run from zero to plus or minus one and express the degree to which, in the rater's judgment, each reference point helps or hinders, strengthens or weakens the rater's attachment to each other reference point in that group situation. Thus, in a class room group each such reference entity[2] as a pleasant classroom, teacher, and fellow students is incompatible with the others to the extent that it is displeasing to the rater or is physically or culturally incompatible with each other in the rater's view. For further examples, incompatible reference entities to one's work group might be low wages, inconveniently distant residences, or a bad-tempered boss.

All the actually observed ratings and all the possible ratings of attachment, cooperativeness, and compatability may be marshalled within one third-degree matrix. This matrix has every reference entity, whether person or reference point, listed as a column heading, every person listed again in the same order as a row heading, and both listed a third time as a "sheet" heading. This provides cells in which to record (a) every person's attachment rating to every reference entity, (b) every person's rating of cooperativeness of all pairs of persons with respect to each reference point, and (c) every person's rating of compatibility between each pair of reference points. This enormous matrix can in practice be reduced as far as desired.[3]

Cervinka proposes the term "groupoid" to denote all the measured

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[2]Perhaps a new term for "reference entity" might be useful, such as "group-gen," meaning any group generator or stimulation binding people together. A "group-gen" would be operationally defined by it algebraic formula as any observed index which positively increases the solidarity index in a specified set of persons and of reference points at one time. Then a "group-antigen" would be any disassociative index which decreases the solidarity index and a "group non-gen" would be a neutral index generating no change in the solidarity of the group.

[3]A usual number of ratings to be entered in the cells is given by $P(2P - 2 + N^2 - N)$, where P = the number of persons and N is the number of non-person reference points. Thus every person writes all the ratings in the parenthesis—rating his attachment to and cooperativeness with every other person (2P —2 ratings) and rating every pair of compatibilities ($N^2 - N$ ratings). Clustering the persons into classes and the reference points into classes can reduce the maximum matrix—which has $(P + N)^2$ cells—down as near as desired to the lower limit of $2P^2 - P$ cells where, with "the group" as the only reference point, every one of the P persons writes one rating of his attachment to "the group" and another rating of his cooperativeness with all his "fellow members" en bloc. A minimal group of two persons would require six ratings by this technique.

attachments and cooperativeness of a set of persons with respect to one reference point. A groupoid is an abstraction measuring the extent to which one reference entity binds people together and so contributes to forming the group. If there are n reference entities in a situation studied, then there are n groupoids interlocked as shown by the matrices to form one group (to the extent of the solidarity index). A groupoid is any set of people interrelated by one kind of relation only, such as Moreno's respondents choosing their roommates. A groupoid is a unitary attachment pattern among a set of persons. In the third degree matrix symbolizing all possible relations within a group, groupoid X is the X array, such as the "sheet" or second degree matrix which cross-classifies all reference entities with each other with respect to that particular groupoid. A groupoid then is all the relations of one reference point and is to be distinguished from a "socius" (or Moreno's "social atom") which is all the relations of one person. The indices in the matrix array of one reference point operationally define the groupoid; the array of one person defines the socius; combinations of both groupoid arrays and socius arrays define the group. The exact analysis of human groups and relations among groups in human society can thus be flexibly and powerfully developed by the dimensional and matrix algebra of socii, groupoids and groups.

APPENDIX

*A Questionnaire on Groups**

Name of group ..... Rater's code number .....
Date of rating .....

After each person and each reference point in the following list, write your ratings as directed below:

Group-Gens *Column a*	*Attachment* (0 to ± 100) *Column b*	*Cooperativeness With Me in Respect to Reference Point No. 1* (0 to ± 1.00) *Column c*	*Compatibility With Reference Point No. 1* (0 to ± 1.00) *Column d*
Persons A			
B			
C			
etc.			
Reference points			
1. Name of group			
2.			
3.			
etc.			

*A version not yet calibrated, for instructed respondents only, and abbreviated to show only cooperativeness with the rater and compatibility with the main reference point (No. 1), which is the name of the group.

RATING SCALE OF ATTACHMENTS

(*A Tentative Draft for Research*)

100	Strongest attachment:	I am willing to risk my life to ..... .
80	Stronger attachment:	I am willing to risk a major amputation to ....., such as losing an arm, or leg, or eyesight.
60	Strong attachment:	I am willing to risk minor amputation to ....., such as losing a finger, my hearing.
40	Weak attachment:	I am willing to risk an injury or disease which may be cured to ..... .
20	Weaker attachment:	I am willing to risk minor discomfort to ....., such as a headache, a night without sleep, loss of a meal, etc.
0	Weakest attachment:	Indifference—I am not willing to risk anything to ..... .

Prefix +, wherever in the space you would write "to get or keep or increase the entity rated."

Prefix —, wherever in the space you would write "to lose or prevent or decrease the entity rated."

RATING SCALE OF COOPERATIVENESS

(A tentative draft for research)

+1.00 Greatest cooperativeness, integration: (the person rated) alone is the cause of my attachment to (the reference entity).

+ .75 Great cooperativeness: (the person rated) contributes sufficiently to make possible my attachment to (the reference entity) but he is not irreplaceable.

+ .50 Medium cooperativeness: (the person rated) appreciably facilitates my attachment to (the reference entity).

+ .25 Little cooperativeness: (the person rated) contributes only somewhat or occasionally to my attachment to (the reference entity).

0 No cooperativeness, indifference.

— .25 Little competitiveness: (the person rated) is occasionally a nuisance, lessening my attachment to (the reference entity).

— .50 Medium competitiveness: (the person rated) is a definite or permanent nuisance, lessening my attachment to (the reference entity).

— .75 Great competitiveness: (the person rated) makes it extremely difficult for me to keep up my attachment to (the reference entity).

—1.00 Greatest competitiveness, conflict: (the person rated) makes it impossible for me to keep up my attachment to (the reference entity).

RATING SCALE OF COMPATIBILITY (TO REFERENCE POINT NO. 1)

(A tentative draft for research)

+1.00 Full compatibility: (the reference entity rated) is a condition or part of reference entity No. 1.

+ .75 Great compatibility: (the reference entity rated) alone is sufficient, although it is not the only one, to ensure my attachment to (reference entity No. 1).

+ .50 Medium compatibility: (the reference entity rated) noticeably or permanently intensifies my attachment to (No. 1).

+ .25 Little compatibility: (the reference entity rated) occasionally or slightly intensifies my attachment to (No. 1).

0 Indifference: (the referehce entity rated) is irrelevant to (No. 1).

— .25 Little incompatibility: (the reference entity rated) occasionally inconveniences my attachment to (No. 1).

— .50 Medium incompatibility: my attachment to (the reference entity rated(definitely or for some duration detracts from my attachment to (No. 1).

— .75 Great incompatibility: my attachment to (the reference entity rated) causes the greatest inconvenience in keeping my attachment to (No. 1).

—1.00 Full incompatibility: I must choose between the two attachments; I cannot keep up both of them.

THE RELATIONSHIP OF DISTANCE TO THE OCCURRENCE OF PEDESTRIAN ACCIDENTS

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This study investigates the relationship between pedestrian accidents on the one hand and the pedestrians' distances from their homes at the time of the accident on the other.[1]

The data were taken from the traffic files of the Police Department[2] of Brookline, Massachusetts, and include all cases of pedestrian-vehicle (i.e. auto, bus, and trolley) accidents in the files for the years 1946 and 1947. There were in all 284 accidents of this type recorded of which 20 cases had to be excluded because of inadequate information. The 264 remaining cases which were used constitute the entire sample to which the present article refers. The distance between the place of residence and point of accidents was measured[3] in each case to the nearest quarter of a mile over the shortest walking route. Since 98.1% of the accidents took place within eight miles of the pedestrian's residence, for convenience, all accidents (i.e. 1.9%) occurring beyond this eight mile limit were excluded, because the latter showed wide scattering in distance.

These data are presented graphically in the adjoining Figure One and are grouped as indicated according to the class middles of the unit selected. Distance is measured logarithmically on the abscissa, and the frequency of accidents is measured logarithmically on the ordinate. The best straight line fitted to these points by least squares had a slope of -1.191 ($\pm .265$) or in equation form $\log y - 1.919 \log x - 2.781$ (*P. E.* $\pm .177$).

From these data it is clear that there is an inverse proportionality between the distance that the pedestrian is from his residence and the frequency of accidents.

The reason for this inverse proportionality is not necessarily because of any preference for accidents near home, but instead, because a person

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[1]A paper written under the direction of the University Lectureship of Harvard University.

[2]I am grateful to Chief M. Tonra for his cooperation in allowing me access to the files, and to all those in the Traffic Department for their help.

[3]I am grateful to the Brookline Engineering Department for allowing me to use their maps and street guides.

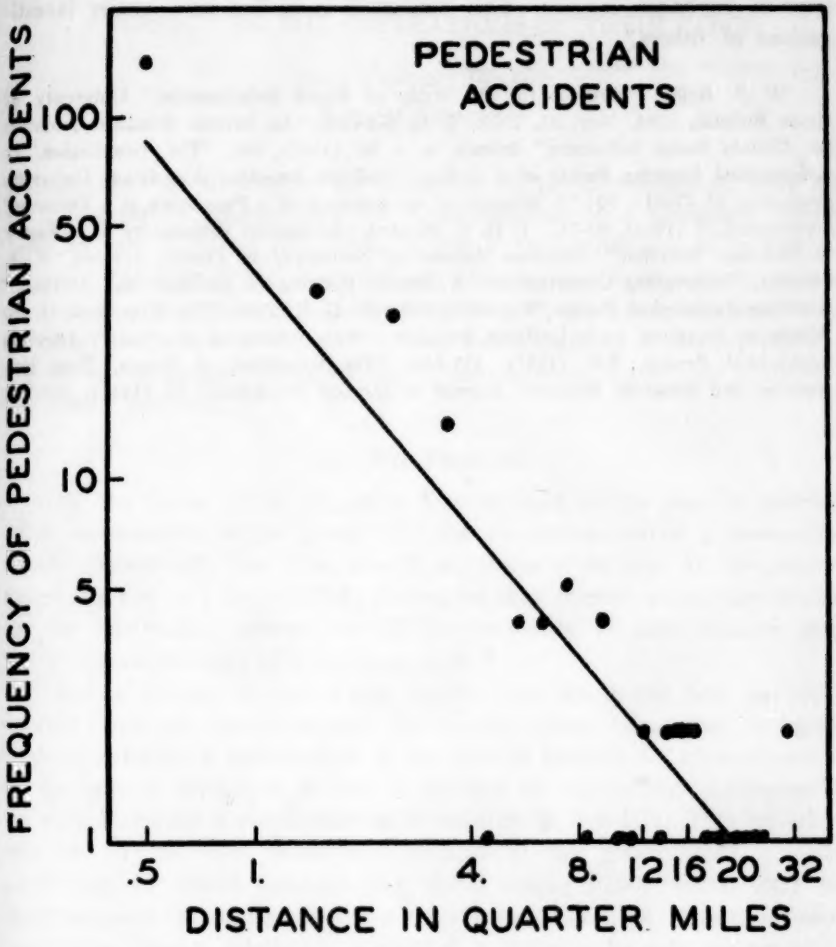

FIGURE 1.
ACCIDENTS TO PEDESTRIANS FROM VEHICLES OF ALL KINDS IN RELATION TO THE PEDESTRIAN'S DISTANCE FROM HOME (BROOKLINE, MASSACHUSETTS, 1946 AND 1947).

is more often near his home and, therefore, has a greater opportunity to suffer an accident there. If we assume that accidents occur at random, then we may conclude that pedestrians are proportionately less likely to take

trips of increasing lengths. This conclusion is in line with earlier investigations of others.[4]

[4]W. J. Reilly, "Methods for the Study of Retail Relationships," University of Texas Bulletin, 2944, Nov. 22, 1929. J. Q. Stewart, "An Inverse Distance Variation for Certain Social Influences," *Science*, n. s. 93 (1941), 84; "The 'Gravitation,' or Geographical Drawing Power of a College," *Bulletin American Association University Professors*, 27 (1941), 70; "A Measure of the Influence of a Population at a Distance," SOCIOMETRY, 5 (1942), 63-71. J. H. S. Bossard, "Residential Propinquity as a Factor in Marriage Selection," *American Journal of Sociology*, 38 (1932), 219-244. S. A. Stouffer, "Intervening Opportunities: A Theory Relating to Mobility and Distance," *American Sociological Review*, V (1940), 845-867. G. K. Zipf, "The Hypothesis of the 'Minimum Equation' as a Unifying Principle: With Attempted Synthesis," *American Sociological Review*, XII (1947), 627-650; "The Repetition of Words, Time Perspective, and Semantic Balance," *Journal of General Psychology*, 32 (1945), 127-148.

ON THE NUMBER AND SIZES OF RADIO-STATIONS IN RELATION TO THE POPULATIONS OF THEIR CITIES

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In 1947 G. K. Zipf in his discussion of the circulation of news set forth theoretical reasons why the circulation-size of a newspaper would tend to vary in direct proportion to the *P* population-size of its city of origin.[1] The gist of his argument was that the probability of occurrence of any class or classes of human events in a *P* population tends to vary in direct proportion to *P;* and so, too, the probability of finding persons for whom the human events will be of news-interest. Later Zipf confirmed his theory empirically.[2]

1. THE PROBLEM

In the course of his argument Zipf referred to the possible parallel of a radio-station whose power, like the circulation-size of a newspaper should theoretically vary directly with the *P*-size of its city. In the present paper, by way of a test of Zipf's theory, we shall present some observations on the relationship between the *K* kilowatt-power of radio stations and the *P* population-sizes of their home cities.[3]

Before turning to the actual observations we should bear in mind several important considerations. In the *first* place, because of stringent Federal controls, a radio-station is not free to increase its kilowatt-power in the way a newspaper is free to increase its circulation; consequently we may anticipate a very considerable variation in our data. This variation will be all the more pronounced because of the government's obvious preference for round numbers (e.g. 5,000 watts, 10,000 watts, etc.) in deciding upon the kilowatt-power of the stations it licenses. As a result any correlation between kilowatt-power and *P* is bound to be only approximate.

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[1]G. K. Zipf, "On Dr. Miller's Contribution", *American Journal of Psychology*, Vol. LX (1947) 284-287.

[2]G. K. Zipf, "On the Number, Circulation-Sizes, and the Probable Purchasers of Newspapers", *ibid.* Vol. LXI (1948), 83-92. See also, his "The Hypothesis of the 'Minimum Equation' as a Unifying Social Principle: with attempted Synthesis", *American Sociological Review*, Vol. XII (1947), 627-650.

[3]In the conduct of this investigation and in the preparation of this manuscript I had the benefit of suggestions from the University Lectureship at Harvard University.

In the *second* place many communities, as we know, have more than one radio-station. Therefore in order to test Zipf's hypothesis, it seemed advisable to deal with the total K kilowatt-power of all the m different radio-stations in each P city—and henceforth K will be so defined—since, after all, the theory seems to relate to the entire radio output. In this connection let us remember that as a city grows in P-size, and correspondingly in the total number of its human events of news-value, the city's radio-station cannot simply increase the duration of its broadcasts, as a newspaper can increase the number of its pages. Instead the city must establish one or more additional stations. Indeed if we assume (i) that *on the whole* radio-stations are on the air about the same length of time (in practice this is not absolutely the case), and if we remember (ii) Zipf's argument that the *diversity* of a community's activity tends in general to vary with the square root of its population,[4] then we may expect theoretically (iii) that the m number of different radio-stations in a city will tend to vary in proportion to the square root of its P population, because (iv) m is in effect measuring the *diversity*, or variety, of the city's total radio offering (since by and large programs are rarely duplicated on different stations of the same city).

There is a *third* consideration that warrants mention in passing. Zipf's theory refers to "items of news-value" such as are found in newspapers. While radio-stations do in fact broadcast news including advertising material, they also broadcast other things such as music, debates, comic programs, etc. These all strive to be "items of interest" for the listener, and in many respects are comparable to the actual contents of a newspaper. For convenience we shall assume that all radio-broadcasts consist entirely of "items of news-value" although the actual structure of broadcasts merits investigation.[5]

With these considerations in mind let us see (1) whether the com-

[4] *Cf.* G. K. Zipf, "The Frequency and Diversity of Business Establishments and Personal Occupations: a Study of Social Stereotypes and Cultural Roles", *Journal of Psychology*, Vol. 24 (1947), 139-148; also his "The Hypothesis of the 'Minimum Equation' etc." *op. cit.* Dr. Zipf informs me that further proofs of this proposition will be presented in Chapters 9, 11 and 12 of his forthcoming *Principle of Least Effort*.

[5] The problem of entertainment has many ramifications. Thus, for example, I have observed a rectilinearity in the lengths of runs of theatrical productions (to be presented in a future publication), *Cf.* G. K. Zipf, "On the Dynamic Structure of Concert-Programs", *Journal of Abnormal and Social Psychology*, Vol. 41 (1946), 25-36.

bined K kilowatt-power of all the m different radio-stations of a city tends to vary in direction proportion to its P population-size, and (2) whether m tends to vary in direct proportion to the square root of P.

2. The Data

We have taken our data from the compilations of *White's Radio Log*[6] for the Winter, 1948, which contain the necessary information about (*a*) the m number of *different* radio stations in each city (i.e. *different* in the sense of operating at a different assigned carrier frequency, regardless of call letters), (*b*) the total combined K kilowatt power of all m stations per city *during evening broadcasting*, and (*c*) the N—number of cities that have a like m—number of different stations. The population-data were taken from the *Sixteenth Census* (1940) which is accurate enough for the present preliminary investigation. Unless otherwise stated, all stations are *AM* (amplitude modulation). There were 1,543 different stations located in 961 different cities of the Continental United States to whose consideration the present article is restricted.

These data are presented in Figure 1 which consists of two parts, the A part above and the B part below.

The A part above represents the combined K-kilowatt power (in hundredths of kilowatts) measured logarithmically on the ordinate (scale at left) for each of the 961 different cities whose P population-sizes (in hundreds of persons) are measured logarithmically on the abscissa. The line A with an ideal $+1$ slope which we expect theoretically has been added for comparative purposes.

The B part below represents the m number of different radio stations in each city measured logarithmically on the ordinate (scale at right), against the logarithm of the population on the abscissa. The line drawn has the theoretically expected ideal .5 slope.

The A-data seem on the whole to be approximating the theoretically expected slope in spite of a very sizeable variation. This variation we have already anticipated in our brief discussion of the rigidity of Federal regulations. A further reason for the variation may be the difference in power for night broadcasting which was alone considered, as opposed to daytime broadcasting. An actual calculation by least squares of the slope of the best straight line fitted to every tenth point of the A-data (in the order of increasing K-size) yielded the slope, $+ .6129$ ($\pm .5764$); or in equation form,

[6] *White's Radio Log*, C. DeWitt White Co., Winter, 1948, Vol. 25, No. 1..

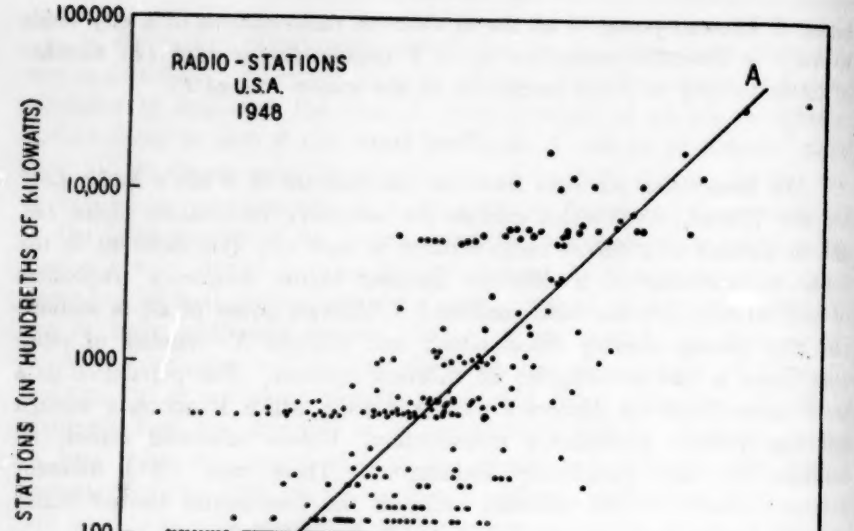

FIGURE 1.

RADIO-STATIONS, U. S. A., 1948 (WINTER).

$\log y = .6129 \log x + .4994$ ($\pm$ .5764). In view of the size of the error (P. E. = .4), the observed deviation from the expected slope may technically be viewed as non-significant, though frankly the author believes that it is significant, and is the result of Federal regulation.

The *B*-data tend on the whole to approximate the ideal .5000 slope of the line drawn for the reader's convenience. Nevertheless a calculation

by least squares of every tenth point of the 961 points of the *B* data yielded the slope, + .3238 (± .1673) or, log $y = .3238 \log x + .6027$ (± .1673). This is a significant deviation from our expected value, and I have no reason to suggest other than that there is theoretically room for more radio stations in the larger cities.

Nevertheless we may not overlook the fact that the calculated slope of the *B* data, + .3238, is about one-half of + .6129 which is the calculated slope of the *A* data. Therefore the *m* diversity of the *B* data does in fact vary in proportion to the square root of the *A*-data.

The *B*-data can also be analyzed from a different angle, if we remember that the rank-frequency distribution of the 961 cities in question is that of a harmonic series.[7] For if the *m* number of different stations of a city varies in direct proportion to the square root of *P*, and if there is a tendency for radio-stations to spring up like newspapers in response to national needs, then, if we rank (*x*) the 961 different cities in the order of their decreasing *m* number of radio stations (*y*), we should have on doubly logarithmic co-ordinates a rectilinear distribution of — .5000 slope. An actual calculation by least squares of every fourth rank (or 240 points in all) yielded the slope — .4842 (± .1028), or in equation form: $\log y = -.4842 \log x + 1.0116$. This seems an unbelievably close approximation that shows that the distribution of radio stations—or *radio coverage*—throughout the Continental United States is structured as a whole, in a manner that is quite comparable to the observed newspaper coverage, if we remember that *m* varies with $K^{1/2}$.

The picture is quite the same for *FM* (i.e. frequency modulation stations) of which about 90% are controlled by *AM* broadcasting companies, and of which virtually 100% are located in cities already served by long established *AM* radio systems. There are 241 different cities that have one or more *FM* stations. If we rank (*x*) these cities in the order of the decreasing (*y*) number of their *FM* radio stations on doubly logarithmic co-ordinates, and calculate by least squares the best straight line for every third rank, we have the slope, — .4957 (± .3001), or in equation form, $\log y = -.4957 \log x + 1.0534$, which is a remarkably close approximation to the theoretically anticipated — .5000 slope. Hence the *FM* stations reveal the same rectilinearity in their rank-frequency distribution as was observed above for the *AM* stations.

[7]For a discussion of this harmonic seriation and bibliography *Cf.* Zipf, "The Hypothesis of the 'Minimum Equation' etc." *op. cit.*

Before closing we should incidentally point out that the slope of the corresponding rank-frequency distribution of the *P*-sizes of the 961 cities that had *AM* radio stations was *about* — 1.2, by eye measure, or slightly more (by .2) than the slope for all communities throughout the nation in 1940.

And before closing we should also point out that radio (and television) are still in the process of growth. A study of these correlations over the years of developing radio-coverage is greatly to be desired, and may reveal further reasons for some of the deviations from expected norms.[8]

3. Summary

In the present paper we have reported the following observations:

1. The total *K*-kilowatt power of the combined *m* different *AM* radio-stations of a city of *P*-population-size in the U. S. A. in the winter of 1948 (evening broadcasting) tended to vary in proportion to a positive power of *P* which, on the basis of a sampling of the data, was + .6129 (± .5764).

2. The total *m* number of different stations tended to vary in proportion to the square root of *K*.

3. When the 961 different cities that had *AM* radio stations were ranked (*x*) in the order of the decreasing *m* number of their radio stations (*y*), on doubly logarithmic co-ordinates, a — .5 slope was observed. The same slope was also observed for *FM* radio-stations when similarly ranked.

Theoretical reasons for the above observations were tendered.

[8] Thus for February, 1942, the calculated slope of the rank-frequency distribution of cities in the decreasing order of their *m* number of *AM* stations was — .4613 (± .0815) with every third point plotted, as opposed to —.4842 (± .1028) reported above for 1948. This difference may well have dynamic meaning in the evolution of radio coverage.

A MEASUREMENT OF THE NUMBER AND DIVERSITY OF PERIODICALS IN 92 AMERICAN CITIES

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It has already been observed by G. K. Zipf that the *n*-number of different business and service establishments in a city of *P* population-size tends to vary in direct proportion to the size of *P;* and that the *m*-number of different kinds of these establishments (i.e., their *m*-diversity) tends to vary as the square root of *P*.[1]

It occurred to us that this same relationship might also be found in the case of periodicals.[2] Therefore we asked, (I) does the *n*-number of different periodicals (i.e., newspapers and magazines) that are edited in a city vary in direct proportion to the city's *P*-size? and (II) does the *m*-number of different *kinds*, or classes, of periodicals vary in direct proportion to the square root of *P* (i.e., $P^{1/2}$)?

(I). *The N-number of Periodicals (Newspapers and Magazines).*

To test the *n*-number of periodicals we had only to count the number per city as listed in Ayer's *Directory of Newspapers and Periodicals,*[3] considering the "location" of a periodical to be the location of its editorial office. For convenience we restricted our inquiry to the 92 cities of the United States which had a population of 100,000 or more in 1940.[4]

In Figure One (*A*-data), the number of different periodicals in a city is represented logarithmically on the ordinate, and the *P* population of that city is represented logarithmically on the abscissa. The best straight line fitted to these points by the method of least squares has a slope of $1.0457 \pm .3065$. Since the theoretically expected slope is 1.00, the data support Zipf's hypothesis.

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[1]G. K. Zipf, "On the Frequency and Diversity of Business Establishments and Personal Occupations: a Study of Social Stereotypes and Cultural Roles," *Journal of Psychology,* 24 (1947), 139-148. See also his "On Dr. Miller's Contribution to the P_1P_2/D Hypothesis," *American Journal of Psychology,* 60 (1947), 284-287; and "On the Number, Circulation-Sizes, and the Probable Purchasers of Newspapers," *ibid.,* 61 (1948), 82-93.

[2]This study was conducted under the general supervision of the University Lectureship of Harvard University.

[3]N. W. Ayer, *Directory of Newspapers and Periodicals, 1941* (Philadelphia: N. W. Ayer, 1941).

[4]U. S. Bureau of the Census, *16th Census of the United States,* Population, Vol. I.

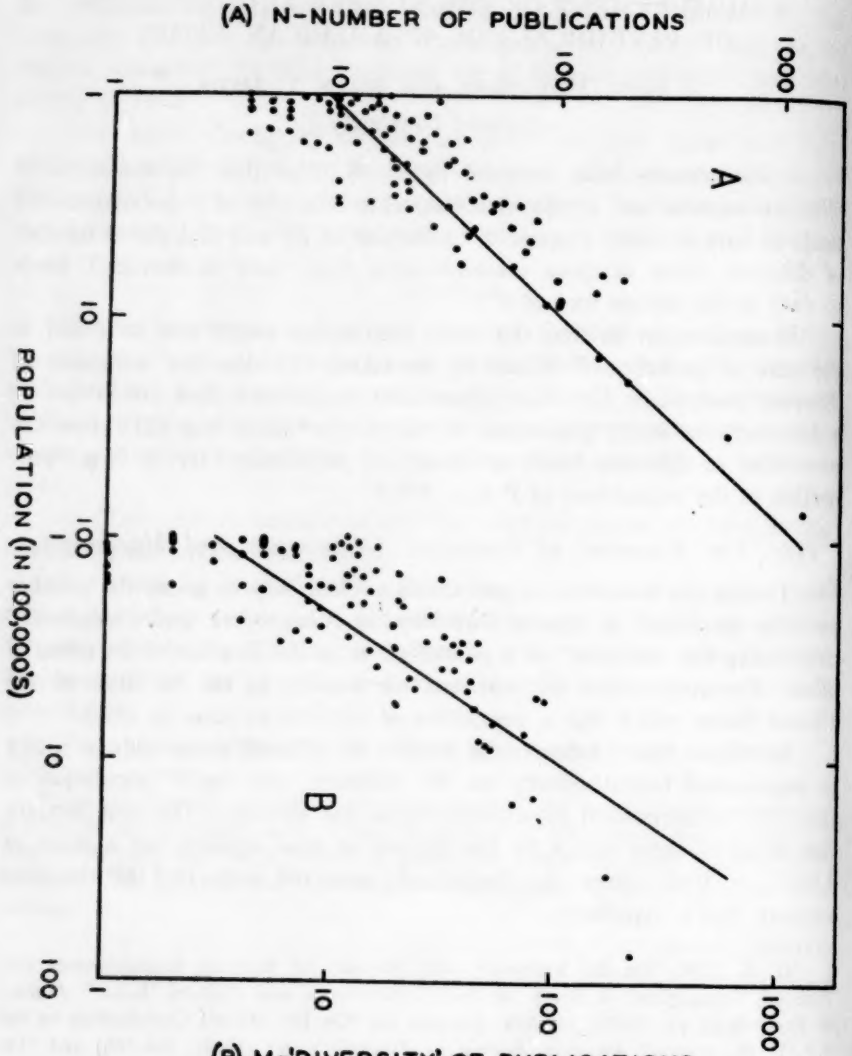

FIGURE 1.

THE NUMBER AND DIVERSITY OF PUBLICATIONS IN SELECTED CITIES OF THE U. S. A., 1940.

(II). *The M-diversity of Periodicals* (*Magazines only*).

The question of the *diversity* of magazines immediately presents a problem: by what criteria are we to distinguish "kinds" of magazines? On the one hand, each magazine is *sui generis;* on the other hand, they all fall into the class, "Magazines". This problem of classification is obviously difficult. In the case of Zipf's study of the *m*-diversity of classes of business-establishments, etc., Zipf simply assumed the validity of the classes of the Bureau of the Census.

However, although Ayer classifies his magazines in a special section (pp. 1154-1282), we cannot assume the validity of Ayer's classification, since he often lists the same periodical in two or more different classes. For example, the *Harvard Theological Review* is classified both as *"Religious"* and as *"Collegiate"*. By actual count, only 6000 magazines are listed by Ayer, but 9000 entries appear in this section. For this reason, the Ayer data are by no means comparable to the data of the Bureau of the Census used by Zipf.

Nevertheless, for whatever it may be worth, we counted the *m*-number of different kinds of magazines that appeared in each of the 92 cities according to Ayer's classification, in which quite obviously a single periodical often appeared as more than one "kind" for the city. In Figure One (*B*-data), this *m*-diversity is graphed logarithmically on the ordinate, against the *P*-population graphed logarithmically on the abscissa. The slope of the best straight line fitted to these points by the method of least squares is $1.5275 \pm .0849$.

It is curious to note that this least squares line with its slope of 1.5 has three times the slope of .5 that Zipf anticipates theoretically. Does this mean in effect that Ayer uses three distinctly different criteria of classification? It may, since an inspection of Ayer's classified section reveals at least the following three main criteria by which magazines may have been distinguished:

(1) Originating group, (e.g., religious, fraternal, collegiate groups, etc.);

(2) Special interest(s) of subject-matter, (e.g., humor, business, international trade, etc.); and,

(3) Degree of generality of subject-matter, (e.g., labor, as opposed to railroad workers).

This explains why the *Harvard Theological Review* is classified both as "Collegiate" and as "Religious"; or again, why the *Railway Carmen's*

Journal is listed under "Railroad" and under "Labor". The reader may find still other criteria used for classification.

Whether the presence of these different and largely discrete manners of classification is responsible for the threefold increase of slope remains an open question. In any event, the obvious rectilinearity of the *B*-data can scarcely be ascribed to chance. As things stand, the *N*-magazines of cities of increasing *P*-size are listed in an *m*-assortment of classes that increases in proportion to the 1.5 power of *P*. Since Ayer's *Directory* is a highly successful publication, and since the classified section in question has been constructed on a utilitarian basis which has presumably received the pragmatic sanction of usage, we can only conclude that the observed ratio is somehow significant.

THE THREE BRANCHES OF SOCIOMETRY: A POSTSCRIPT

Introduction

The historians of the year two thousand will probably credit sociometry as the true beginning of a meaningful and useful sociology. It was the unique contribution of sociometry to have discovered and systematically investigated the fundamental nature of the "socius" and henceforth to have laid the foundation of a dynamic science of the group.

Systematics in sociometry is an orderly collection of logically related principles and facts so arranged as to express the whole range of measurable truth in the departments of interpersonal and intergroup relations. Dimensional analysis of sociometric data is only *one* method by means of which the relationship of sociometry to systematics may be shown. Although the body of sociometric knowledge to be ascertained is ultimately one and the same, the conditions under which the true facts emerge differ widely and therefore the same phenomena can be mirrored and represented by many kinds of systems. The real test for the usefulness of dimensional analysis is in the future; it must prove that it can add to sociometric knowledge and that it is a better language for communicating sociometric findings than the already existing methods of representation.

Definition

The chief methodological task of sociometry has been the reorientation of the experimental method so that it can be applied effectively to social phenomena. Sociometry has been defined as "the mathematical study of psychological properties of populations; the experimental technique of and the results obtained by application of quantitative methods"; also as "the inquiry into the evolution and organization of groups and the position of individuals within them";[1] the "measurement of person to person, person to group and group to group relations." As the "science of group organization"[2] "it attacks the problems not from the outer structure of the group, the group surface, but from the inner structure,"[3] the group depth. The

[1] "Psychological Organization of Groups in the Community" by J. L. Moreno, Yearbook of Mental Deficiency, Boston, 1933, pp. 51.

[2] "Conference on Group Method", The National Committee on Prisons and Prison Labor, Meeting of the American Psychiatric Association, Philadelphia, 1932, pp. 15. Second edition of this conference on Group Method is contained in "Group Psychotherapy," Beacon House, 1945.

[3] "Application of the Group Method of Classification", 1932, pp. 90.

definition of sociometry was thus in accordance with its etymology, from the Latin, but the emphasis was laid not only on the second half of the term, i.e., on "metrum" meaning measure, but also on the first half of the term, i.e., on "socius" meaning companion. Both principles had been neglected but the "socius" aspect had been omitted from the deeper analysis far more than the "metrum" aspect.

Position in a System of Social Sciences

The phrase sociometry has a linguistic relatedness in construction to other, traditional scientific terms, biology, biometry; psychology, psychometry; sociology, sociometry. From the point of view of systematics it is the study of group structure preparatory to the topical fields, sociology, anthropology, social psychology, social psychiatry, etc. It is concerned with the "socius" *and* "metric" problems common to all social fields, human and subhuman. Sociometry as a science is an ideal; in its broadest outlook it engulfs but is not identical with any particular trend.

Historical Position of Sociometry

Conceptual and theoretical illuminations derived from many sources and minds, G. Simmel, J. Baldwin, C. Cooley, G. H. Mead, F. Znaniecki, W. Thomas, E. Burgess, but the decisive inspiration came in 1923 from a practical experiment in spontaneity research, in 1931 from a practical experiment in community organization, with devices which permitted simultaneous diagnosis, therapy and measurement of interpersonal and intergroup relations.

The official start in 1923[4] began when a small group of individuals were studied in interaction and the means of measuring this was invented; the socius and the metrum problems were simultaneously attacked. Both approaches were methodically synthesized into a single operation. The material phase of this operation developed later into the spontaneity, situation and sociometric tests of today. The measurement instruments, the interpersonal and movement diagram (Moreno, 1923)[4] developed later into the interaction diagram (Lowell J. Carr, 1929); the sociogram (Moreno, 1931) developed into the sociomatrix (1937). *Hot* (socius) and *cold* (metrum) sociometry were one. As I have pointed out in previous publications[5] the macrosociological has prevailed for centuries without any true

[4]With the publication of "Das Stegreiftheater" J. L. Moreno, Gustav Kiepenheuer Verlag, Berlin. See pp. 87-95, interpersonal and movement diagram. American Edition "The Theatre of Spontaneity", 1947.

[5]"Who Shall Survive?", see particularly chapter on *Social Microscopy*, 1934.

advance in the social sciences. It apparently appealed to a superficial sense to think of mankind as a sum of so and so many, approximately two billion individuals, as if it would have no social structure of its own. It appealed also to the presociometric social measurists to count the individuals and be satisfied with it and consider a mass as a sum of individuals. If we take 1923 as the conceptual and 1933 as the official origin of sociometry in literature, it took sociometry twenty-five years in order to arouse the awareness of social scientists everywhere, that there is something like a group structure which is *more* than the sum of the individuals participating in it and that this new world can be measured. This revolution in knowledge did not come from macrosociological ventures à la Comte, Marx, von Wiese or George H. Mead, but from the stubborn attention given to small social systems by methods of social microscopy. Whereas macrosociological approaches have been either sterile or to a large extent intuitive, the number of important discoveries made by sociometric studies are considerable although, to the detriment of progress of the social sciences, not fully appreciated, not even by sociometrists.

Three Branches of Sociometry

Since its conscious inception it has developed three departments of research, (a) dynamic or revolutionary sociometry—when the new sociometric order replaces the presociometric order; this procedure is all-embracing, it combines social change, diagnosis and measurement; (b) diagnostic sociometry—when the new sociometric order may or may not be put into operation as being impracticable in a particular social setting; it excludes social change for this reason but it includes measurement as a matter of course; and (c) mathematical sociometry—sociogram, sociomatrix, action matrix, and their generalized mathematics. The three divisions overlap and some workers have made contributions to each department.

Every science refers to a constellation of facts and the means of their measurement. Without adequate means of how to discover the facts and without some means of measurement a science does not exist. The preliminary step in the development of every science is to realize the conditions under which the significant facts emerge. How to accomplish this differs from science to science. How to realize the conditions under which physical and biological facts emerge, their description and careful observation and study, is comparatively well known. The problem of creating the conditions under which the significant facts of human relations emerge is far more complicated. It requires nothing short of revolutionary methods. The

reasons why there should be such a great difference between the preliminaries required for the social sciences as compared with the physical sciences is not immediately obvious. In the physical sciences, as the subject is inanimate, most of the emphasis has been placed upon the mechanical, physical aspects of the situation. We do not expect from the subjects, stone, water, fire, earth or planets, suns and stars, to contribute anything themselves to the study of their own selves; except in the mythologies, we do not ascribe any soul or personality to them, or at least we do not do it anymore. Therefore, the metaphysical relations which might exist between the planets and stars, to each other as mythological soul-bearing actors, does not concern the science of physics. This problem does not change much when it comes to cellular or animal organisms, f.i., in experiments with rats, guinea pigs, etc. The social investigator, the one who sets up the experiment and interprets the data is a human being and not a guinea pig or a rat. The rats or guinea pigs, so to speak, have no part in such experiments as actors in their own behalf. All such experimental designs are human designs and not designs of guinea pigs or rats. If a poetic mind à la Swift could describe how rats feel about each other and what the experiments which men make on them mean to them, it would probably be within our artistic but outside of our scientific comprehension. One could say here that we are trying to measure the behavior of rats as it "is" and not what rats feel it is, but this does not change the methodical difficulty which we encounter when we apply the same techniques of observation to the relationships of men among themselves. With animal societies one can take the stand that they are given and pre-ordained just like the individual animal organisms are, but human society is not automatically given and pre-ordained. Although deeply related to physical and biological conditions, it has a structure whose creation and development is initiated from within and must be studied from within.

Sociometric Generalizations

Sociometric research of small, microscopic social systems has led to a number of hypotheses which have been confirmed by a number of investigators independently.

(A) *The "tele" phenomenon.* Tele is the factor responsible for the degree of social gravity operating between individuals and groups of individuals. It is responsible for the degree of reality of the social configuration above chance. Tele (t) is increased in direct proportion to the number (n) of pair (p) relations and in inverse proportion to the number of unrecipro-

cated (u) relations. Transference (tr) increases in direct proportion to the number (n) of unreciprocated (u) relations and in inverse proportion to the number of pair relations (p).

(B) *The law of the "social atom".* The hypothesis states that as the individual projects his emotions into the groups around him and as the members of these groups in turn project their emotions toward him, a pattern of attractions and repulsions, as projected from both sides, can be discerned on the threshold between individual and group. This pattern is called his "social atom". "Every individual's social atom retains a significant *consistency* in its ratio of positive reciprocation and its interchoice ratio between two time points. The incidence of patterns at one time and at a later time in the same community is a relatively constant factor in the structure of attractions and in the structure of rejections which characterize it. There are found, in a given community, specific choice and rejection patterns and they show an orderly distribution within it. Yet, while the incidence of certain patterns may be relatively constant, the findings further show that the individuals occupying particular patterns at one time may or may not be the same individuals who occupy them at the later time."[6]

(C) *The "network" phenomenon.* More or less *permanent* structures which bind individuals into channelized formations, so-called "psychosocial networks" have been discovered. The forming of public opinion, the transmission of rumors, the "grapevines" cannot be understood by the investigation of individual attitudes only, even if the number of attitudes explored go into millions. The spark which binds individuals together changes the picture entirely because it moves the process from the individual-attitudinal-isolationistic level up to the sociometric level of correlations. Proofs that networks exist have been firmly established in 1932[7] through a study of rumors and an epidemic of runaways. The function of networks is architectonic, economic and regulative. They may well be compared with the circulatory system of blood transmission in human anatomy. In a community of 387 individuals, for instance, five networks were found in operation (each network consisting of 94, 85, 81, 67, 60 individuals). Notwithstanding that this discovery was made fifteen years ago (to my knowledge) all rumor and public opinion studies made since are stubbornly limiting themselves to the individual-attitudinal approach as if nothing had happened.

(D) *The "sociodynamic law".* The sociodynamic law is divided into

[6] Helen H. Jennings, "Leadership and Isolation", 1943.
[7] "Who Shall Survive?", pp. 256-265.

a first and a second part. The first part states that the income of emotional choices per capita is unevenly divided among the members of the group regardless of its size or kind; comparatively few get a lion's share of the total output of emotional choices, out of proportion with their needs and their ability to consummate them; the largest number get an average income of choice within their means to consummate them and a considerable number remain unchosen or neglected. The scores when plotted form a J curve, the great majority of the population receiving scores below chance and a relatively few obtaining scores much higher than chance. Though an equal number would have been expected on the basis of chance the proportion of isolates was generally greater than the proportion of stars.

The second part states that if the opportunities of being chosen are increased by increasing the size of the group and the number of choices per capita, the volume of choices continues to go to those at the top end of the range (the "stars") in proportion to the size of the group and to the number of choices permitted per capita, maintaining or increasing the gap between the small star group, the average group and the neglected group. The excess "profit" gained by the already overchosen members must be ascribed to a chain and network effect which operates in cases of non-acquaintance (with the chosen individual) in addition to the score based on acquaintance (with the chosen individual). The direct factor is proximity choice, the indirect factor, a symbolic choice. An individual, A, may score high in his face to face group, but because of his "role" (he may be a baseball player, an actor or a senator) his ultimate score may turn out to be a multiple of the initial score (role corresponds here to what is usually meant by status; status is too much of an abstraction, but role implies a living and concrete function).

The sociodynamic law affects all human relations, it operates, (a) on the interpersonal level and (b) on the intergroup level. It is found in some degree in all social aggregates whatever their kind, whether the criterion is search for mates, search for employment or in socio-cultural relations. Its effect may change in degree but it is universally present, appearing like a halo effect, *inherent in every* social structure. A particularly significant effect takes place on the level of economic relations. The "surplus" choice becomes analogous to the surplus value observed by Marx in the process of accumulation and production of capital. The distorted profit picture in economic relations is a reflection of the distorted tele picture on the interpersonal and intergroup level. The social revolution on the class level is therefore a displacement from the microscopic choice and rejection picture

to the macroscopic level. Social revolution on the macrosociological level is only *part* of the struggle. Marx was operating on the gross, macrosociological level of events. He often used intuitively near-sociometric ideas, a "macro" sociometrist. He was therefore rarely altogether wrong, but also rarely altogether right. Being unaware of the social microscopy of modern sociometry, he committed many grave errors[8] of insight. It would be interesting to envision what effect this knowledge would have had upon his theory and method of social revolution. It appears at least that the place of revolutionary action should have been reoriented towards the smallest units of human relations, the social atoms, the primary receptacles of "preferentiation", in order to become truly and permanently effective. The sociodynamic effect does not cease to be effective in a socialistic system of society.

(E) *The "sociogenetic law".* The sociogenetic law states that the highest forms of group organization have evolved from simple ones: between the simplest patterns of groups formed by infants and the most complex formed by adults there are numerous intermediary stages. Parallel with this process of social differentiation a characteristic differentiation and growth of sociosexual structure takes place within the group. The course of differentiation may differ from one culture to another, from a pre-literate to a modern society, but a common basic core of evolutionary patterns and a parallel trend should be found in all of them.

(F) *The "law of social gravitation".* People I (P1) and People 2 (P2) move towards each other—between a locality X and a locality Y—in direct proportion to the amount of attraction given (a1) or received (a2), in inverse proportion to the amount of repulsion given (r1) or received (r2), the physical distance (d) between the two localities being constant, the facilities of communication between X and Y being equal.

The formulas of Stouffer and Stewart, based on statistical analysis of number and distance, even if correct in themselves, are unsatisfactory because of their symbolic character, leaving the people out, the dynamics of interpersonal and intergroup relations. Stewart's finding can be easily integrated into the sociometric formula which then would read as follows:

People 1 (P1) and People 2 (P2) move towards each other in direct proportion to the amount of attraction given (a1) or received (a2), in inverse proportion to the amount of repulsion given (r1) or received (r2) and in inverse proportion to the physical distance (d) between locality X

[8] J. L. Moreno, "Marxism, Comptism and Sociometry," SOCIOMETRY, Vol. VIII, No. 2.

and locality Y, the residences of P1 and P2 respectively, the facilities of communication between X and Y being constant.

The attraction-rejection volume from a population, for instance of Beacon, to another population, for instance of Newburgh and vice versa, has two restraining factors to meet: (a) the volume of self-attraction (Beaconers for Beaconers, Newburghers for Newburghers) and (b) the volume of attraction-rejection between Beacon and Newburgh and other towns, for instance Poughkeepsie, Peekskill, Albany, New York, Chicago, Los Angeles, etc. Instead of talking here about attraction-rejection volumes we could talk in terms of the social gravitation quotients between two localities, their SGQs. By means of sociometric tests we can calculate the SGQs between two localities, the magnitude of the SGQs in reference to populations in other localities does not change the figure of the SGQs between A and B The total volume of social feeling and interest existing between individuals and groups throughout the human society is not determined by the number of individuals and the distance between them. Two sets of two groups (AB, CD) of the same size may vary many times in the social feelings they have for each other and the potential amounts of social feelings they could make available. When giving the sociometric test, for instance to the Beacon-Newburgh twin, we may arrive at the total volume of social feelings they have for people in various other localities of which their own relation is only a portion. The result can be expressed as follows: total volume of A-R (Attraction-Rejection) minus volume A-R towards other localities equals volume of A-R between Beacon and Newburgh. *The gravitation volume of physical distance is already inherent in these figures.*

J. L. MORENO
Editor

ANNOUNCEMENTS

American Sociometric Association—1948 Elections

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Third National Conference on Psychodrama, Sociodrama, Sociometry and Group Psychotherapy

This conference is the third in the series dedicated to "Training in Human Relations", taking place at the Moreno Clinic, Beacon, New York. It starts September 4th and continues through Labor Day, September 6th.

1948. Every one of these conferences develops around the vital interests and requirements of the delegates themselves. The aim of each conference is to acquaint the delegates in a minimum of time with the principle of the modern group action and training methods.

Fee, including room, board and tuition for the three-day conference and training sessions: $35.00; $25.00 for two days, $17.50 for one day. For further information or registration write to: Moreno Clinic, P.O. Box 311, Beacon, New York.

Books Received

"Tribes of the Liberian Hinterland" by George Schwab; Peabody Museum, Cambridge, Mass., 1947, pp. 536 and numerous photographs, Price $7.50 paperbound, $10.00 clothbound.

"Public Reaction to the Atomic Bomb and World Affairs", Cornell University, Ithaca, New York, April 1947, pp. 310, paperbound, no price indicated.

"The Psychology of Ego-Involvements", by M. Sherif and H. Cantril, John Wiley & Sons, Inc., New York, 1947, pp. 525. $4.00.

"Foundations of Psychology", edited by Edwin G. Boring, Herbert S. Langfeld and Harry P. Weld, John Wiley & Sons, Inc., New York, 1948, pp. 632, $4.00.

"Society, Culture and Personality", by Pitirim A. Sorokin, Harper & Brothers, New York, 1947.

MORENO CLINIC

PSYCHODRAMATIC INSTITUTE PROGRAM—1948-49

Part Scholarships Available
Special Rates for Veterans

In 1948 it will be twelve years since the Psychodramatic Institute opened its doors. During this period its Therapeutic Theatre has been applied to treatment, training and research.

The Institutes of Beacon and New York have organized facilities for the enrollment of one hundred students for the course during the coming year. All students are to receive instruction and training in sociatry, socio- and psychodrama, sociometry and group psychotherapy, covering among others, the fields of: Nursery School, Child Guidance, Public School Education, Juvenile Delinquency, Speech Disorders, Intercultural Relations, Leadership Training, Family and Marriage Problems, Music Therapy, Therapeutic Films, Rehabilitation of the Returned Soldiers and Their Families, Community and Religious Problems.

The objectives of the program are: (a) Training of directors of psychodrama, sociodrama and group psychotherapy in the conducting of sessions; (b) Training auxiliary egos (therapeutic and research actors), of group interviewers and group lecturers; (c) Training of social analysts in clinical and actual situations; (d) Seminars covering the fields of psychodrama, sociodrama, sociometry, group psychotherapy and therapeutic motion pictures; (e) Research and field projects in psychodrama and group psychotherapy, with study of methods and analyzing and classifying psychodrama, sociodrama and sociometric materials.

Teaching and training will be given jointly at the auditorium of the New York Institute and at the Therapeutic Theatre of the Moreno Clinic.

Students fall under two categories: Category A: the Beacon Group-Enrollment in this group is limited to 30 students. Classes and sessions begin on June 1st and last 4 months, until October 1st. Students of this group receive their room, board and training at the Psychodramatic Institute at Beacon, N. Y. The fee for students of this group is $60.00 per week, $240.00 for a four weeks' stay. Directorial work is part of the training of this group. Application for enrollment in this group should be in our hands by May, 1948, with registration fee of $5.00. Members of the Beacon group may attend New York sessions at a small additional expense.

B: The New York Group-Students live in New York (those who have private residence) or commute from out of town and attend the classes at the New York Institute at 101 Park Avenue. These courses are continuous throughout the year. For this group sessions and classes are given 3 times a week in the late afternoon and evening, so that they are able to pursue a professional occupation during the day, or other academic studies. The full enrollment capacity of this group is 80 students. The weekly tuition fee is $20.00, the fee for a 12 weeks' course is $240.00; with additional training in directorial capacity the fee runs to $360.00. There are a number of half scholarships available. Students who qualify for and obtain such scholarships pay half the tuition for the 12 weeks' course, $120.00 and $180.00 respectively. New York students may attend weekend sessions at Beacon, N. Y., staying at the Beacon Institute for the weekend if room is available, for an additional fee. Such weekend training is meant especially for students interested in directorial techniques and work with mental patients. All students are required to pay a registration fee of $5.00 in advance.

J. L. Moreno, M.D., Director of the Psychodramatic Institute in Beacon and New York City, assisted by a staff of instructors, will conduct the seminars and sessions. Students will be permitted to use the library at the Psychodramatic Institute. Every student is expected to formulate and work out a research project related to his own field of application, under guidance. Upon completion of the course every student will obtain an official acknowledgment from the director as to the duration of the course and the accomplishments of the student.

Students interested in training courses in 1948 and 1949 may file their applications *now*; they will be placed on a preference list which will assure their admission.

ENROLLMENT CARD FOR STUDENTS

MORENO CLINIC

PSYCHODRAMATIC INSTITUTE

I enroll for a.....weeks training course at Beacon, New York

from.....till.....

.....and enclose herewith the registration fee of $5.00.

Name, in full (please print) .....

Address .....

Fill in, tear off and mail to Moreno Clinic, Psychodramatic Institute, Beacon, New York